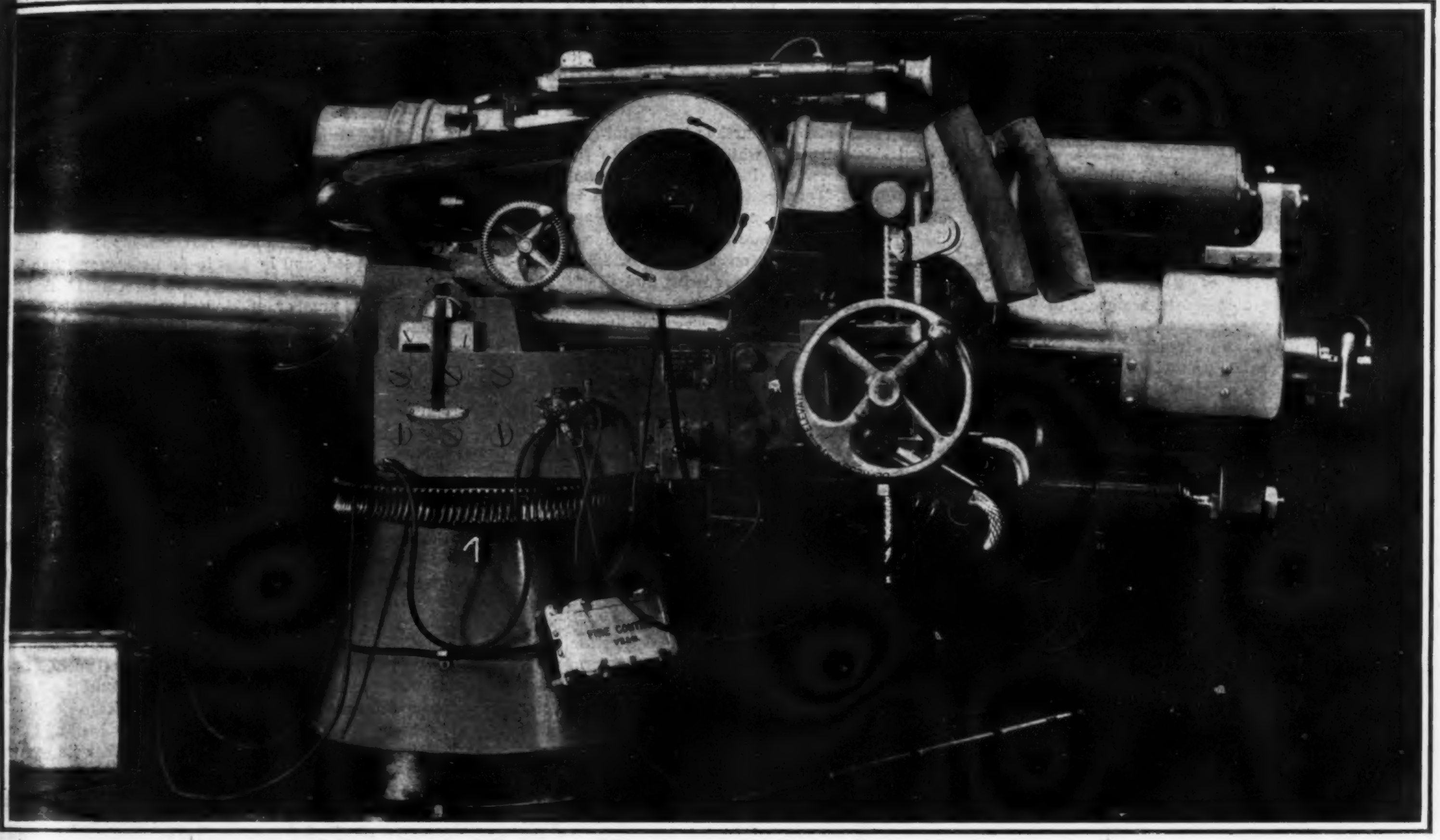
SCIENTIFIC AMERICAN SUPPLEMENT. No 1701

Entered at the Post Office of New York, N. Y., as Second Class Matter.
Published weekly by Munn & Co. at 361 Broadway, New York.
Charles Allen Munn, President, 361 Broadway, New York.
Frederick Converse Beach, Sec'y and Treas., 361 Broadway, New York

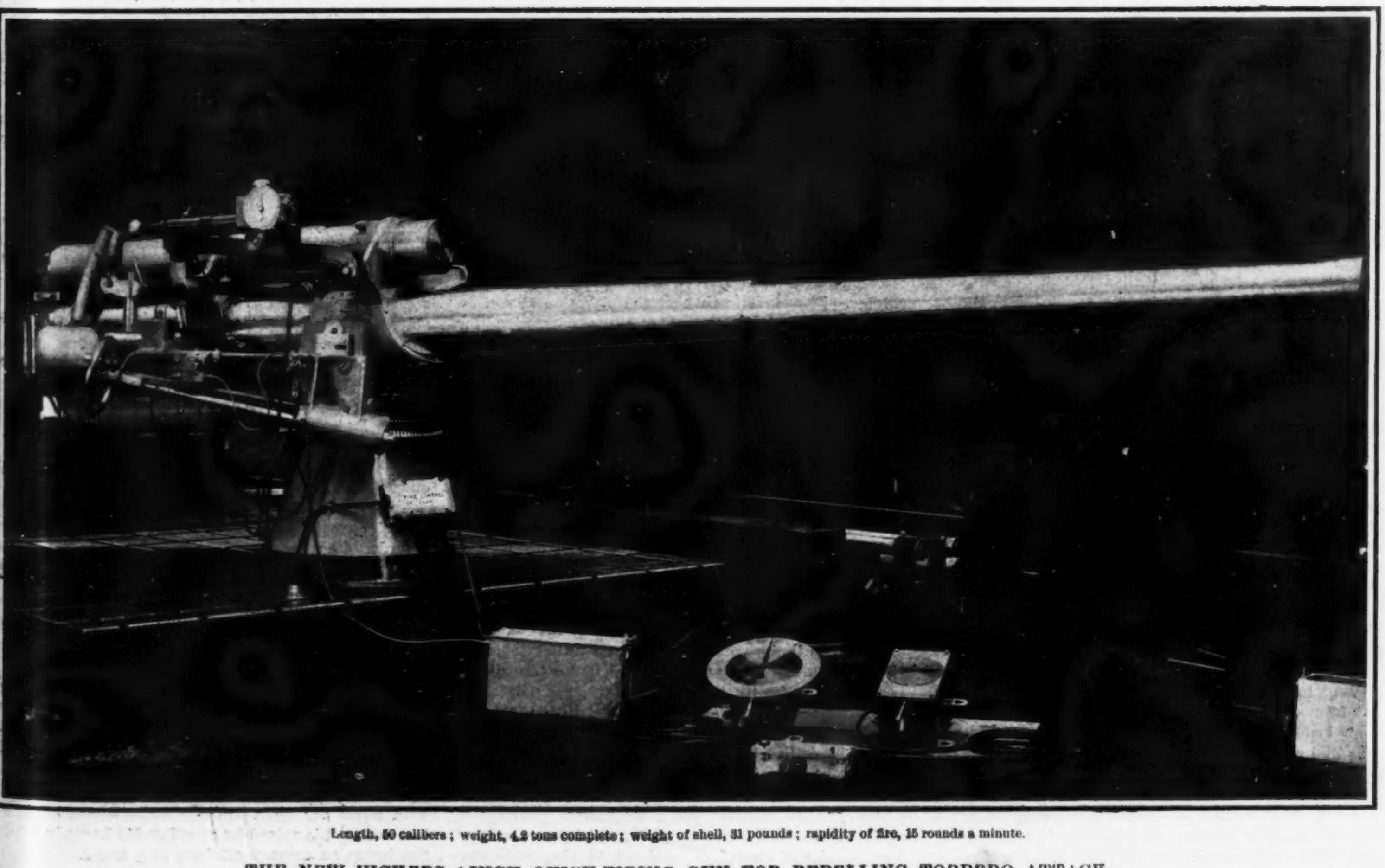
Scientific American, established 1845.
Scientific American Supplement, Vol. LXVI., No. 1701.

NEW YORK, AUGUST 8, 1908.

Scientific American Supplement, $5 a year.
Scientific American and Supplement, $7 a year.



THE BREECH MECHANISM OF THE NEW VICKERS 4-INCH QUICK-FIRING GUN.



Length, 50 calibers; weight, 4.2 tons complete; weight of shell, 31 pounds; rapidity of fire, 15 rounds a minute.

THE NEW VICKERS 4-INCH QUICK-FIRING GUN FOR REPELLING TORPEDO ATTACK.

THE NEW VICKERS 4-INCH QUICK-FIRING GUN

A RIFLE FOR REPELLING TORPEDO ATTACK.

BY THE ENGLISH CORRESPONDENT OF THE SCIENTIFIC AMERICAN.

One notable outcome of the prevailing tendency in naval construction for the all-big-gun warship has been the evolution of a new type of light arm for the purpose of repelling torpedo attack. The latest weapon of this type has been designed by Messrs. Vickers, Sons & Maxim, Limited, the well-known armament builders, and constitutes one of the most important among the ordnance exhibits at the Franco-British Exhibition. For this especial duty this new arm should prove highly effective. Its total weight complete with mounting is 4.2 tons, and it fires a 31-pound shell with a muzzle velocity of 3,030 feet per second and a muzzle energy of 1,975 foot-tons, at 15 rounds per minute, so that at a range of 3,000 yards it would prove a formidable offense to mosquito craft.

The gun is of 50 calibers, its total length being 208.45 inches, the length of bore being 201.15 inches. The breech motion is of the latest Vickers single-motion pattern. The breech screw is unlocked by the horizontal swing of the hand lever, which also swings the breech screw into or out of the gun. The threads of the breech screw are disposed in segments of varying radii, which design affords a greater proportion and a more even distribution of threads as compared with the ordinary type of interrupted screws. There is a long arm connected to the breech screw, which is operated by means of a crank pinion mounted in the carrier, and this crank is provided with a roller which engages in a cam groove formed in the arm. The form of this groove, together with its position in relation to the crank pinion, is such that the maximum possible power is exerted when seating the obturator, and a locking point is secured when the breech is closed. The crank pinion is geared to the hand lever, the latter being pivotally mounted on the carrier, enabling it to swing in a horizontal plane and to lie close up to the breech when the mechanism is locked. Obturation is obtained by a plastic pad having a protecting disk and rings. The obturator is retained at the front of the breech screw by an axial vent, which at its rear extremity takes the firing gear. The latter comprises separate electric and percussion locks, which are interchangeable in working, carried in a box slide mounted on the axial vent.

The feature of these firing gears is their absolute safety, facility of assembling, and effectual extraction of the tube. A crank pinion and link operates the locks, causing the lock frame to slide in the box slide when the breech screw is being unlocked, actuates the extractor, ejects the fired tube, and uncovers the vent to admit of the insertion of a new tube, while the firing gear has a special device for retracting the firing pin or needle before any movement of the lock frame in the box slide. There is a double-action trigger pull to the percussion lock, so that the gun can be fired from either side. The breech mechanism is also fitted with a light shot tray mounted on the face of the breech, and operated by a crank on the hinge pin of the carrier. As the breech mechanism is swung open this shot tray is pulled in a lateral direction, and by means of grooves which engage with studs in the face of the breech, is raised automatically to the loading position.

A forged steel plate of U section forms the cradle of the mounting, having bronze bearing strips at the front and rear ends on which the gun slides during recoil. The cradle is fitted with front and rear bronze caps for supporting the running-out spring case and also the cross-connected sights. The cradle trunnions are of steel screwed into position. The recoil cylinder is screwed to the underneath rear portion of the cradle, the screws passing through lugs formed on the recoil cylinder. The rear end of the latter is screwed to receive the rear cylinder plug, which is fitted with glands and packing for the forged steel piston rod. The valve key is of the ordinary rectangular pattern, with its upper edge formed of suitable varying depth to control the recoil and to give an approximate uniform pressure in the cylinder. The rear end of the piston rod is secured to the lug on the breech ring of the gun.

The retarding ram is of manganese bronze, and is secured to the front end of the cylinder. There is a flat formed on the ram to permit the liquid to escape from inside the piston, and also to check within certain limits the running out under the influence of the springs. A hole fitted with an adjustable plug is bored through the center of the ram, and this plug can be removed from outside the cylinder and be adjusted, thereby altering the speed of the running out of the gun. The case containing the running-out springs is secured to cradle caps, and by means of a simple arrangement the spring column may be drawn out of the front end of the spring case complete for examination or any other purpose without taking off the initial compression. The carriage is of forged steel of the usual shape.

Bolted on the left-hand side of the carriage is a steel side bar carrying the elevating gear and shoulder pieces, and a gun metal side bar on the right-hand side carrying the traversing gear and shoulder piece. The elevating gear is so arranged as to enable elevation and depression to be carried out quickly, in order to follow the motion of the ship.

The electric firing gear has two pistol grips attached to suitable adaptors, which are fixed to the elevating gear bracket on the left-hand side of the mounting. Rheostats and connection pieces lead to the dynamo circuit pistol grips, and night lights are fixed on both sides of the mountings on the side bars, while the box contacts are on the right-hand side at the breech end, and a cable for firing and illuminating the night sights is disposed on each side of the mounting, together with suitable cable eyes for fixing.

The sighting gear comprises two telescopes on either side of the mounting, controlled by gearing to give the requisite movement in the vertical and horizontal planes. The two telescopes move synchronously by the gearing, being directly cross connected. The sights are carried by brackets formed on the two cradle caps, rigidly connected together by means of the running-out spring case of the mounting. The complete sighting gear together with the cradle caps can be withdrawn or replaced on the cradle without any interference with the sight adjustments. The deflection dial and gear are mounted on the right-hand side, and the range dial and gear on the left-hand side of the gun mounting. The telescopes are of two types, one 5 to 12 variable power for night use, and the other 7 to 21 variable power for day use.

The pointer of the range gear is electrically operated by means of a small motor actuated by current received from a range transmitter placed in the fire-control station. The electric motor and gear are carried in a small box oscillating on a journal formed on the back of the range dial casing coincident with the center of the dial, and the oscillation of this box imparts a certain additional movement to the dial pointer. Oscillation is controlled by a bell crank receiving its movement from a groove cut in the back of the range dial. One arm of the crank is formed as a quadrant, and fitted with a sliding piece to which is pivoted one end of the link connecting to the oscillating box. As the sliding piece is moved along the quadrant the movement to the oscillating box is increased or decreased, and in this manner compensates for variation in muzzle velocity, attributable to wear of the gun barrel or loss in temperature of the charge. The position in which to fix the sliding piece is shown by a graduated strip provided on the quadrant.

Normally, the system of using the sight is as follows: The pointer is electrically moved from the transmitter in the fire-control station, and the sight is elevated until the arrow on the dial agrees with the pointer. The sight is then at the elevation shown on the transmitter, with the necessary correction for change in velocity due to wear of gun barrel, etc. When the electric control is interrupted, the pointer is used as an index and the sight is elevated until the desired range is indicated opposite the pointer. The deflection gear is also fitted with a pointer controlled by a transmitter in the control station.

The principal features of the range control transmitter are a hand-operated rotary controlling switch and an electric motor geared to a pointer traversing round a dial on the front of the containing box. The motor drives the pointer spindle carrying the pointer through gearing, and special arrangements are incorporated to prevent the motor armatures overheating. The dial is graduated similar to the range dial for the gun sight. The range being determined, the handle is operated until the pointer of the transmitter indicates the correct number of yards. As the motor transmitter is synchronized with that of the sight, the pointer on the latter moves to a corresponding position, thereby showing the requisite elevation. The deflection transmitter is similar to the range transmitter both in its design and operation, only the dial is graduated to correspond with the deflection dial on the gun sight.

The gun is mounted on a steel plate pedestal of conical form fixed to a base plate, which has a central boss bored and slotted to receive a bearing plate containing a ball race, the latter supporting the pivot stem of the carriage, and upon which the whole of the training mass revolves.

The weapon forms a very handy and powerful weapon for the special work for which it has been designed. The weight of charge and projectile is 44.25 pounds, of which the projectile weighs 31 pounds. It will penetrate at muzzle 16 inches of wrought iron plate and 12.4 inches of mild steel plate. The rapidity of its fire would enable it to riddle a destroyer at a range of 3,000 yards.

TURBINE PROPELLERS.

The literature of the screw propeller is very large, and those who please to refer to text-books and papers will find that they contain quite precise information concerning every conceivable aspect of marine propulsion. The designer need not be at a loss for a moment. Given displacement, wetted surface, cross section, and proposed speed, and he has to do little more than look down the columns of figures in a table to find the proper area, number of blades, velocity, pitch, and diameter of the screw which will give him the best attainable results. Most unfortunately all this information is untrustworthy. But that is the misfortune, not the fault of those who supply it. The most that can be expected from it is that it will enable the designer to fit a screw which will neither lock the engines up nor permit them to run away. In point of fact most engineers rest quite content if, intending that their engines shall indicate a stated horse-power on a stated number of revolutions, they comply with these conditions. What the efficiency of the propeller may be is quite outside the contract—and properly so, because the man does not live out of a lunatic asylum who will guarantee any percentage for a propeller.

With all this ignorance is, however, combined a certain amount of knowledge which prevents great mistakes from being made outside the royal navy. Ships of war present special difficulties, because no two of them are quite alike, and it is not always possible to fit them with what seems to be the best and most efficient propellers. But in the mercantile marine some certainty of practice has been arrived at; and if it cannot be proved that any given ship—say, an Atlantic liner—is driven by the best possible screw, it is usually quite as difficult to prove that she is not. It took many years to reach this conclusion, and now the turbine has arrived to upset everything. It has, of course, from the first been understood that the propeller dominated the situation. It is not too much to say that the turbine could not be used at all with paddle wheels, and the screw is only less unfit in degree, not in kind. The trouble is that the propeller must be run at an unsuitably high number of revolutions per minute. Normally the draft of water and the speed of the ship settle in the main the diameter of the propeller and the pitch. When the turbine is used the diameter and pitch are determined by the turbine, not the ship. One result is that very small diameters are essential. So are fine pitches and blades which nearly fill up the whole area of the circle described by their tips. Still, even here out of chaos something was being crystallized. It has even been stated that it was possible to design a propeller which would have a fairly high efficiency at the first attempt; and not only this, it has also been said that some certainty had been reached as to the proper number of propellers to be employed and the right places for them. It is never safe, however, to prophesy unless you know; and the last voyage of the "Mauretania" to New York bids fair to upset all calculations, and open up a new field for speculation and research.

For some time past the "Lusitania" and the "Mauretania" have been endeavoring to break each other's records. On a recent westward voyage the "Lusitania" made the highest average speed for the whole run, the longest single day's run, and the shortest time over the summer course, from Daunt's Rock to the Sandy Hook lightship. The distance is 2,889 knots. The length of the winter course is 2,781 knots. Her average speed was 24.83 knots. The record run for a single day was 632 knots. The steadiness of her running is shown by the successive days' steaming, the total distances run on each entire day being 622, 625, 632, and 628 knots. On the day that she made the record run, the "Lusitania" maintained an average speed of 25.42 knots, which is equivalent to over 29 land miles per hour. In her last westward trip she has beaten this record by covering 641 knots in twenty-five hours, an average of about 25½ knots.

Let us remind our readers that these ships are each fitted with four propellers, two being placed in the position ordinarily taken by twin screws, except that they are closer together, and two in the wings and much farther forward. All the propellers revolve outboard. The two central propellers are driven by the low-pressure turbines, the other two by the high-pressure turbines. The total power is about 68,000 horses, or, say, 17,000 horse-power for each screw. Now, on her last voyage to England the "Mauretania" broke one of her high-pressure propellers—that on the port side. It was found impossible to provide and fit a new one in time for her booked trip, and she left Liverpool on Wednesday, the 27th May, with only three propellers. It was not expected, of course, that a good run would be made, but, astonishing to say, from noon on Saturday, the 30th, to noon of Sunday, the 31st, she ran 635 knots, representing an average speed of 25.5 knots. This beats all previous records except the "Lusitania's" last.

So far there are no details of any kind advanced. It is said, however, that all the steam was passed through one high-pressure turbine, from which both the low-pressure turbines were supplied. We have here a number of most interesting questions awaiting answers.

The facts go to show that the performance of the ship is better with three propellers than with four, and this is the more remarkable because the port propeller being absent, the ship must have carried a starboard helm to keep her head straight, and so the rudder resistance would have been augmented. Did the absence of a propeller represent a deficiency of 17,000 horse-power, and if it did, how did it come to pass that she was actually the better of this loss? If not, then the remaining propellers must have been run at much more than their usual speed; and this seems necessary to explain the undiminished efficiency of the two low-pressure screws. But how was this practicable without a serious increase in the boiler pressure, unless, indeed, the turbines normally run throttled? Is it after all possible that the ship has two propellers too many? That, in fact, she would do better with two than with four, and that the wing propellers do more harm than good? It is well to remember that all attempts to gain propelling power by placing propellers in the wake of each other have been failures. We may mention the "Bessemer," which had four paddle-wheels, two ahead and two astern of the swinging saloon. The after wheels were terribly inefficient, revolving as they did in the current flowing astern from the forward wheels. In several of the earlier turbine boats two or more propellers have been mounted on the same shaft, with unsatisfactory results. It seems to be beyond doubt that the wing propellers of the great liners must "feed" the central propellers to some extent. It is to be hoped that the phenomenon may be investigated to the fullest extent. The event is practically unique. It accentuates our ignorance of the whole nature and inwardness of screw propulsion, and it may be found to have very far-reaching effects on navigation by means of turbines.—The Engineer.

METALLIC SODIUM.

ITS ELECTROLYTIC PRODUCTION.

BY C. CHABRIÉ.

WITHIN a few years the price of metallic sodium has fallen from 60 cents to 25 cents per pound. This reduction has been brought about by the adoption of improved methods of production. At present, the metal is obtained chiefly by the Castner and the Borchers processes. In the former, fused sodium hydrate is electrolyzed at a temperature of 617 deg. F. An iron vessel is used, through the bottom of which the cathode is introduced, a tight joint being made by the layer of solidified sodium hydrate that always covers the bottom of the vessel. The anode is composed of a number of pieces of iron which surround the cathode and are attached to the cover of the vessel. The anode pieces are separated from the cathode by a screen of wire gauze, in the form of a tube, which envelops the cathode. The metallic sodium collects inside this tube and floats on the surface of the fused soda, whence it is removed, from time to time, with the aid of a perforated skimming ladle. There is a simultaneous disengagement of oxygen, which can be collected and utilized.

In the Borchers process the sodium hydrate is replaced by sodium chloride (common salt). The apparatus (Fig. 1) comprises two communicating vessels. The larger vessel *C* is made of refractory clay and contains the anode, while the smaller cathode chamber *B* is of iron. The connection between the vessels is made by the metallic ring *A* and the clamps *D* and *E*. The ring can be cooled in such a manner as to solidify a layer of the fused salt and thus form a tight joint. Chlorine escapes through the pipe *H* and the fused metallic sodium flows off through the pipe *K*. A fresh supply of fused chloride is continually furnished by the perforated reservoir *R*, which is filled with lumps of salt.

Ashcroft has modified this process by dividing it into two parts. In the first part, a lead cathode is employed in the electrolysis of fused sodium chloride. The result is the formation of an alloy of lead and sodium which is transferred to another vessel, where it serves as an anode in the electrolysis of fused sodium hydrate, in which operation metallic sodium is deposited on the cathode.

The apparatus (Fig. 2) consists of two compartments, *M* and *N*. The first vessel *M* is lined with bricks of magnesia, silica, or clay and is heated with gas or electricity. The salt is introduced through the funnel *C*. The electrolyzing current enters by the electrode *E* and escapes through the fused alloy of lead and sodium which covers the bottom of the vessel. When this alloy has become sufficiently rich in sodium it enters the pipe *S* through the holes *I* and flows to the second vessel *N*, which is closed, in order to exclude air, and is gently heated by a gas flame. In this vessel the alloy of lead and sodium becomes the anode.

The cathode is a ball of nickel *R* attached to a copper tube which serves as an outlet for the current. The lead-sodium alloy escapes from the pipe *S* through the holes *K*, and the molten lead, after having been freed of sodium, returns to the vessel *M* through pipes (not shown in the diagram) which are so arranged with respect to the pipe *S* that the alloy is cooled and the lead is heated in flowing from one vessel to the other. By the use of this regenerative system each vessel is kept at its proper temperature (that of the first vessel *M* being the higher) with a minimum expenditure of heat. The metallic sodium, after being deposited on the cathode, rises to the surface and escapes through the pipes *G*.

The Ashcroft process requires an electromotive force of 9 volts, twice the voltage employed in the Castner process, but it also produces twice as much sodium per ampere of current, so that the expenditure of electrical energy per pound of sodium is the same in both

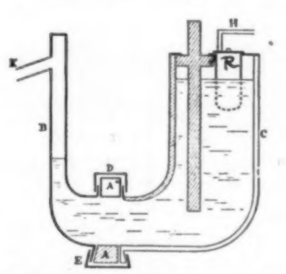


FIG. 1.—BORCHERS APPARATUS FOR THE PRODUCTION OF SODIUM FROM SALT.

processes. Yet the cost of production, which runs from 10 to 14 cents per pound in the Castner process, is only 5 to 9 cents per pound, according to the cost of electrical power, in the Ashcroft process.

An additional source of revenue in the Ashcroft process is the liberated chlorine which may be used in the manufacture of bleaching powder, potassium chlorate, chloroform, etc. Hence this process is considerably more economical than any other now in use.—Translated from La Science au XXme Siècle.

NEW REACTIONS WITH "THERMIT" COMPOUNDS.

A PAPER having this title was contributed by Dr. Hans Goldschmidt, of Essen, to the fifteenth annual gathering of the Bunsen Gesellschaft at Vienna. The following is a summary of the chief points of the paper as prepared by the author:

Defining the "thermit" reaction more closely than in previous papers, the author stated that it covered the reactions between reducing metals or alloys and other metal-holding combinations, whereby the reaction when

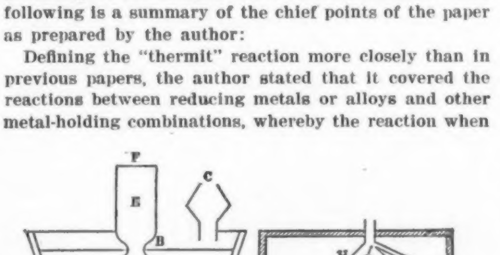


FIG. 2.—ASHCROFT APPARATUS FOR THE PRODUCTION OF SODIUM FROM SALT AND SODA.

once started at some point in the mixture by external ignition, proceeded further without external aid, and yielded (1) complete oxidation of the more active metal; (2) a liquid slag; and (3) the reduced metal or metals, as a homogeneous regulus—free from the more active reducing metal.

The metal cerium behaved like aluminium, as Müthmann had observed, but silicium did not behave in accordance with the definition of a "thermit" metal as given above. Reactions similar in character to the "thermit" reactions can indeed be started between silicium and the higher oxide combinations of certain metals, but the regulus obtained is never free from silicium.

When metallic calcium was first placed upon the market, it was hoped that some use would be found for it, in place of aluminium, as a reducing agent in metallurgical operations. It was soon found, however, that calcium was similar to manganese in its "thermit" properties; the reaction was too violent, and the slag of CaO was too infusible, to yield a satisfactory separation of the regulus or metal.

A mixture of calcium and silicium yielded, however, more satisfactory results. The reaction speed of the calcium was lowered by the more slowly acting silicium, while the slag obtained when using the mixture was comparatively easily fusible. The author has, therefore, carried out a very large number of experiments in order to determine the limits within which a mixture or alloy of calcium and silicium yields reactions of technical utility and importance.

Aluminium had a similar effect to silicium upon the reaction speed of the calcium, while a mixture of all three metals also yielded a good separation of the reduced metal or metals. Manganese might also be employed in the place of calcium. (These points were illustrated by experiments.)

In order to prepare the mixture or alloy of silicium and calcium, it was found necessary to obtain first both metals in the pure state and then to melt them together. The simpler and cheaper plan was to heat silicium with lime. The first-named metal then reduced the lime and formed a calcium silicide having the composition one-third Ca and two-thirds Si. This combination was found to be unacted upon by the atmosphere, showed a bright fracture, and possessed a specific weight of about 2.0. Not only can this new combination be employed for the ordinary "thermit" reductions, but it is also of technical importance in the steel industry, since it can be used as a substitute for aluminium and manganese to remove oxygen and other occluded gases. The chief advantage appertaining to the use of this combination lies, however, in the fact that it yields a slag with a much lower melting point—1,350 deg. C.—than aluminium or manganese, and one which separates, therefore, more quickly and completely from the molten metal.

The manufacture of this new alloy—calcium silicide—is about to be commenced on a large scale, using a process patented by the author.

A correspondent to the Times Engineering Supplement states that a well perfected process for the construction of artificial gems has been developed by the Deutsche Edelstein Gesellschaft, at Idar, Germany. Instead of building up a stone from fragments, by which means the so-called "reconstructed rubies" are obtained, this company is said to make flawless rubies and other precious stones of perfect color and brilliance, and of great size, directly from the chemical elements. These gems possess all the chemical and physical properties of the real stones, and are indistinguishable from the genuine, even by experts. They can, moreover, be obtained in the most perfect tints, and of any required size.

ELEMENTS OF ELECTRICAL ENGINEERING.—XXIII

STORAGE BATTERIES. PART II. SWITCHBOARD ARRANGEMENTS.

BY A. E. WATSON, E.E., PH.D., ASSISTANT PROFESSOR OF PHYSICS IN BROWN UNIVERSITY

Continued from Supplement No. 1699, page 54.

WITH the positive and negative plates duly assembled in order in the jars or tanks—the positive of one set being attached to the negative of the next—the solution may be poured in, but not unless it is fully cooled. All the cells should be filled without unnecessary delay, for the fact of plates standing uncharged in the solution, as already stated, tends to the formation of undesired sulphate. In consequence of some inevitable action of the acid upon the materials, it is likely that some sizzling will take place, but this is not injurious.

All connections to the switchboard terminals having also been made, the charging should be started immediately after filling the last cell. In Fig. 120 is shown a diagram that represents the essential connections, and while succeeding diagrams illustrate further details and additions, it is to be inferred that these elements, too, are included as a matter of course. In this, a shunt-wound dynamo is represented with its main terminals attached to the lower contacts of a double-pole single-throw switch, with a rheostat in the field circuit, whereby, within the scope of the machine, the voltage may be adjusted to any desired value. Between the upper contacts of the switch the storage cells are connected, with an ammeter of the permanent magnet type included in any convenient place. A small double-pole double-throw switch is shown under the voltmeter—also of the permanent magnet sort—the hinges being connected to the instrument, the upper terminals to the upper ones of the main switch, the lower contacts similarly to the lower ones of the larger. By this it is seen that when the main switch is open, the act of closing the small switch in the upper position, as shown, will attach the battery to the voltmeter and the pressure may be read. By closing the switch in its down position the voltage of the dynamo may be read. It will be noticed that the right hand of the two terminals of each instrument is marked +; this is the regular construction of the Weston voltmeters and ammeters, and in the diagram care has been taken to represent consistent directions. Since the battery has a definite polarity of its own, it is highly important to have instruments of the sort that will respond to the particular polarity. In charging, the positive pole of dynamo must be connected to the positive of battery, and the voltmeter is relied upon to reveal the poles, and the ammeter to indicate whether current is going into the battery or coming out of it.

If the plates are in such a completely discharged condition that when first set up they give no deflection at all upon the voltmeter, the circuit must be traced from the set of plates that is properly to be positive to the right-hand terminal of the voltmeter, the dynamo set for a low voltage, and the charging current rather cautiously brought to its normal strength. About 20 to 25 square inches superficial area of positive plates is to be allowed per ampere—this general statement being modified by the directions ordinarily sent out with batteries from the various manufacturers. Assuming that the battery does at first, as certainly it will on subsequent use, show a definite potential, this particular value is to be noted, and then the voltmeter switch is to be turned to its lower position, and the field rheostat of dynamo adjusted until the voltage from this source is equal to that of the battery. It may happen that with all the connections as shown, except that the main switch must of course be as yet unclosed, the dynamo polarity may be such as to deflect the voltmeter needle the wrong way. This shows that the polarity of dynamo needs reversal, and the truthful prediction of this condition is one of the valuable qualifications of this type of instrument.

To remedy such a contingency as the wrong polarity of machine, it is not necessary to change the wiring or switch connections; while such means would be effective, they would be, especially in case of large conductors, decidedly inconvenient. The magnetism itself can be readily shifted. To do this, in case of a bipolar dynamo as shown in the diagram, remove the brushes belonging to one set, then close the main switch. Current will then flow from the batteries around the shunt field winding in the direction to give the right polarity. If the machine is multi-polar, having several sets of brushes, it may be more convenient to remove a main connection from the switch, or from the terminal board on the dynamo itself. After thus letting the current flow for a moment, open the main switch rather slowly, so as to allow the self-inductive electromotive force to dissipate itself gradually, then replace the brushes or other connection, and the voltmeter should unfailingly indicate the correct polarity.

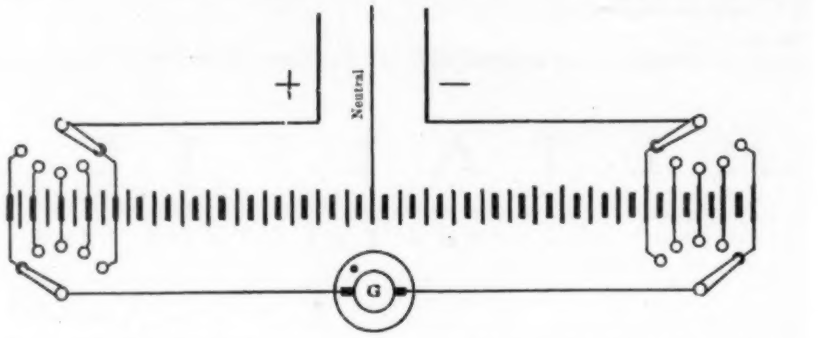


Fig. 122.—Diagram Showing Double Set of Storage Cells for Operating Three-wire System.

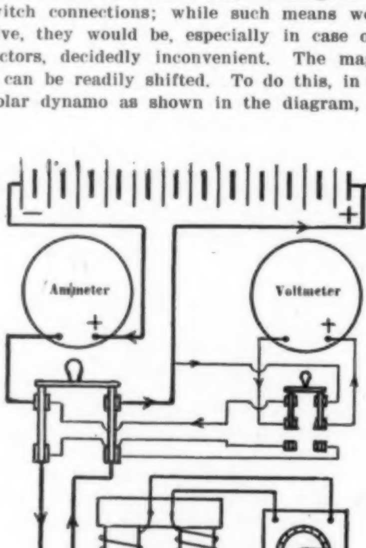


Fig. 120.—Simple Diagram of Connections for Storage Battery Charging.

Set the dynamo voltage the same or slightly higher than that of the battery, close the main switch, and then raise the voltage of dynamo until the proper current is indicated by the ammeter. Say, in a given case there were thirty cells, each consisting of four positives and five negatives, each 6x8 inches. The area of one side of a plate will be about 50 square inches, giving for both sides 100 square inches, and consequently 400 for the set. Allowing 20 to 25 square inches per ampere, the normal charging current can economically be between 16 and 20 amperes. When the battery is in ordinary good condition, but awaiting charge, the total voltage may be slightly below 60; it should not be allowed to get below 55, or 1.8 volts per cell. The dynamo should be set for about 60 volts, but directly after closing the main switch there may flow only a small current. Within a short time 2.2 volts per cell will be needed to overcome the natural counter electromotive force of the cell, and about 0.3 volt more to overcome the ohmic resistance. With a new battery the charging is supposed to continue with as few interruptions as possible, until the voltage, after shutting off the charging current, is 2.4 per cell, and the gravity of solution is 1.21. Succeeding charges may stop with the value of 2.5 per cell. This voltage must be read immediately after opening the main switch, for after a little wait, the excess of hydrogen bubbles in the solution passes off, and the potential falls to 2.2. After a slight current has been drawn off, the voltage still further falls to its normal value of 2 per cell.

In stopping the charge, operations just the reverse of those in beginning the charge should be taken. The main switch should not be abruptly opened, for this unnecessarily burns the contacts, and in case of large currents, may produce a blinding flash. It is orderly and simple to turn resistance into the field rheostat until the ammeter indicates no current, and then open the switch. It will be recognized that the operation of connecting a dynamo for charging a battery, or of disconnecting it, is exactly like that of operating a dynamo in parallel with other dynamos.

In case the dynamo potential is made lower than that of the battery it is normally charging, current will run backward into the machine; but in case the field has a plain shunt winding, as shown in all these diagrams, no harm will result, for the armature will merely continue to turn in the same direction, though now as a motor. For this reason it is well to let the ammeter have its zero mark in the middle of the scale, then plainly, charging currents will deflect the needle to the right, and discharging currents to the left. Of course this action needlessly runs out the battery, so a common device to include in the main line is an underload circuit breaker. The construction closely imitates that of the ordinary overload circuit breaker, which may also be included in the outfit, but with the functions reversed, so that a current anything below a predetermined minimum will release an armature and open the line.

A series dynamo is quite unfitted for charging a battery. As just explained, the voltage of the machine must be adjusted to a particular value before closing the main switch, yet confessedly the series machine must have its circuit closed before it can generate at all. Of course a temporary artificial load could be arranged, until the voltage was correct, then the battery connected in parallel with this, and then the artificial load disconnected. Even then the means

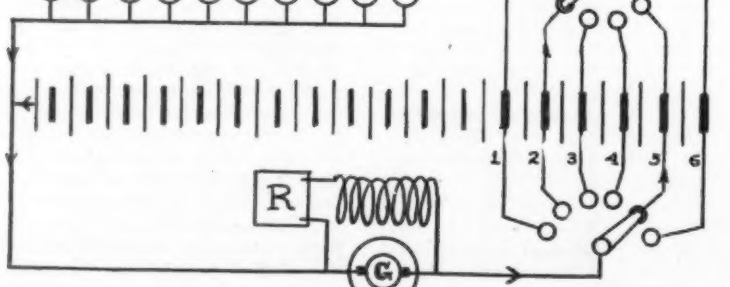


Fig. 121.—Diagram of Connections for Storage Batteries with End-cell Switch Method of Control. Sixty Cells Charging Under Pressure of 150 Volts.

for further adjusting the voltage would not be apparent, and if for an instant did the dynamo voltage get below that of battery, the current would flow out of battery around the field magnet in the direction to reverse its polarity, when generator and battery would at once be connected in series on a ruinous short circuit.

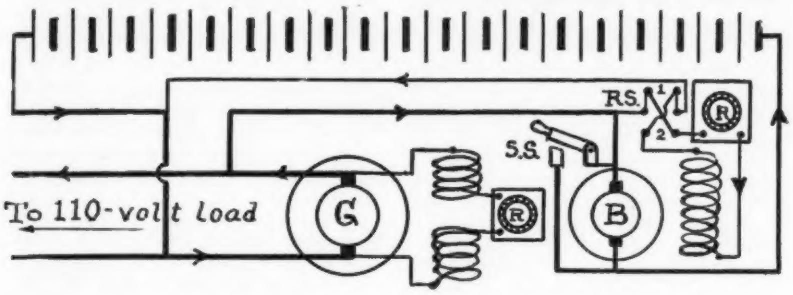


Fig. 123.—Operation of Batteries Under "Booster" Method of Control.

If a compound-wound dynamo is used for such charging—and occasionally it may be possible to find such—there is the ever-present danger that the current will flow in the wrong direction in the series portion, reverse the polarity, and cause serious damage to the armature or the switchboard apparatus. The experience of central stations in this respect is conclusive, that shunt-wound generators are alone practicable. Though thus compelling hand regulation of the field rheostat, the fact that a battery load is fairly constant renders the actual amount of attention required as infrequent. Many stations have changed their compound windings to shunt, and some of the very largest generators built have only these simple field coils—a notable resort to the type first adopted and for years tenaciously adhered to by Edison in his central station equipments.

In the diagram and manipulations just explained, no mention has been made of the uses to which the batteries were to be put. The act of charging them is not of course the final object, but, at will, to get the current out. Without further appliances the installation would be quite helpless to maintain the particular service desired. For an experimental laboratory, it might be sufficient merely to lead wires from the various connections between the cells, thereby allowing any desired number to be connected to the apparatus at hand.

For central and sub stations, and even small plants, the device known as the "end-cell" method of control is largely used, and gives great flexibility to the system to which it is connected. A graphical representation of its peculiarities is given in Fig. 121. The system is supposed to consist of a load of lamps or other devices, operating at a fixed normal voltage, yet the battery charging, so that for certain hours, later, it may assist the generator to carry the maximum load, and then at another time, when the load is small enough, the engine may be shut down altogether, and the battery do the work alone.

All these desirable conditions are readily filled by the arrangements shown. Assume the practical case of a country residence, a hotel, or apartment house desiring an isolated electric lighting plant. The lights should be available at any hour of the day or night, but for reasons of economy the engine should not be run after midnight. If 110-volt lamps are to be used, and the minimum voltage of 1.8 per cell is admitted, the number of cells required will be sixty-one. To charge the battery an allowance of 2.5 volts per cell must be provided, or the dynamo must be able to generate 155 volts. This is far in excess of what the lamps could directly stand, yet during the charging, the 110 volts only must be supplied to the lamp circuit. Taps must be led from a certain number of cells near the end of the series, and connected to a double switch, in the order shown, and by proper manipulation of the contact arms, the desired regulation may be secured. In the case taken, the excess voltage would be 45, and at the charging value of 2.5 volts per cell, this would mean that eighteen cells should be thus connected. The diagram shows only six, but the principle is obvious. As the end cells are less in circuit during the discharge than the main set, they are more quickly charged, and so can soon be removed from circuit, and the voltage of generator proportionately reduced. The charging of these end cells is further accelerated by the necessity, as will be noticed, of the current for the entire lamp load, in addition to the regular charging current, passing through whatever cells are included between the two movable contact arms.

When the arms rest on similarly numbered contacts, the battery may discharge in parallel with the dynamo, and then, when the latter is disconnected, the battery alone carries the load, additional cells being occasionally cut into circuit, as a watchman may see fit from observation of the voltmeter.

In making an end cell switch, precaution must be taken to have the end of the arm narrower than the space between contacts. In case considerable current is flowing, this necessitates an objectionable flash, but the alternative case would be worse, for at the instant when the arm simultaneously touched two contacts, the cell between them would be on a short circuit, with the result that the contacts might melt and stick together, and also injure the cell. To avoid both flashings and short circuits, it is common, in case of large installations, to make the contact arm double, the two arms insulated from each other, and then connected through a suitable resistance. During the transition from one position to the next this resistance momentarily carries the main current and also a local current from the cell concerned, but the flash is avoided, the lamps experience no wink, and the cell is not quite short circuited. For very large installations carbon blocks serve as excellent resistances for this momentary interposition.

There is another method of arranging cells for a private or small installation, somewhat resembling the one just described, with which it might readily

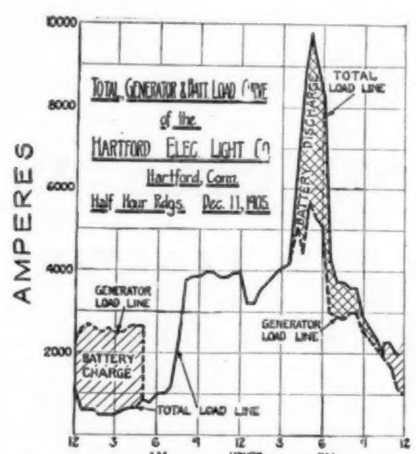


Fig. 124.—Typical Load Curve for an Electric Lighting Station with Storage Battery Adjunct.

be confused, yet having some essential differences. It is called the "counter-cell" arrangement. In this there would be a full set of cells, numbering, for an analogous case, sixty-one, as before, and a second set of eighteen cells, connected in opposition to the main set. A contact switch with eighteen points would be connected so as to include more or less of these. The dynamo is supposed to be directly connected with the main set, while the lighting circuit is attached to one end of the main battery and to the hinge of the contact switch. By this means, whatever current is used for the lamps has ordinarily to pass through some of the counter cells, always in the direction to charge them. This represents some expenditure of energy, and an original expense for the extra cells. The only excuse for prescribing such an installation would be where the demands were small, and the apparatus was intrusted to unskilled hands. All the main cells would be charged alike and used alike, while the other cells, though used variably, would always be passing current in the charging direction.

The extension of the end-cell method of control for an ordinary two-wire system to the extensively used three-wire system is readily accomplished. Indeed, it may be said that the storage battery adjunct to a central station has really encouraged the development of this system. The serious objection to the former necessity of always having to run the dynamos in pairs is eliminated by tapping off the "neutral" from the middle point of the battery, and charging the entire set with a single generator of double the usual potential. Double end-cell switches must be used at both ends of the battery. Figure 122 clearly shows the arrangement, the positions selected for the switches being those for allowing all the cells to charge, and yet impressing the minimum possible voltage on the line. Sometimes additional end-cell switches are connected in parallel with the others, so that by independent shifting of the arms different voltages may be impressed upon different feeders.

A good illustration of this particular method of operating a three-wire system is that of the Edison Electric Illuminating Company, of Boston, in their Atlantic Avenue station, where six 300-volt generators, of 1,600 kilowatts capacity each, are in regular operation, connected to local loads and to various storage battery sub-stations in different places in the city.

A tolerable, but uneconomical arrangement of a battery to be charged from a circuit of fixed potential, yet to discharge at that same value and supply the lights when the engine is not running, is offered by having the cells in two equal groups, say for 100 volts, two sets of thirty-one cells, and connecting them in parallel for charging and in series for discharging. A rheostat would need to be included in the circuit under both conditions. Such a method of operating has been adopted for small apartment houses or for pleasure yachts, in which the dynamo ordinarily supplies the load, but for a very few lights in the latter part of the night the battery can be called upon. Occasional adjustment of the rheostat by the watchman usually suffices to give all the regulation needed.

For large installations, in which the dynamo ordinarily carries the day load, and for part of the night, and the battery is to finish out the service unaided, or the battery is to assist in carrying the "peak" of the load, the most convenient and economical method of control is that by the aid of "boosters." A booster is a dynamo of apparently distorted proportions. It is considerably smaller than the main generators, but its armature windings, or bars, may be equal in size to those on the largest machines, and the commutator may be designed to pass fully as much current. While the booster may be directly driven by a steam engine, as are the main machines, it is not common to do so, but to drive it by an electric motor. Convenience in position and ease of starting and stopping are thereby secured, and in addition allow the engines to be of large size only. Central station managers dislike the use of small engines, ordinarily of low economy. Electric motors are of high efficiency.

The main generator, *G*, in Fig. 123, is supposedly operating at the normal voltage and supplying the demands of the customers as typified by the 110-volt load. A circuit tapped from the "bus" bars is led through the armature of the booster, *B*, to the set of storage cells to be charged. If, however, the booster is not desired, its armature can be cut out by use of the short-circuiting switch, *SS*. To put the booster into use, this switch is opened, and the motor started. The field-magnet of the booster is separately excited from the same main circuit. It will be observed that in this field circuit a rheostat and reversing switch are included. With this switch in one position, say the upper, current will flow around the field to make the voltage generated by the booster added to that of the main generator; in the other position, the voltage of the booster may be reversed. The rheostat may be varied to adjust the voltage to any desired extent.

In case storage batteries are added to an existing installation in which dynamos alone had previously been used, the booster method of control is usually imperative, for otherwise the voltage would fall considerably short of that required for economical charging. The scheme is preferable, too, for many original plants, for thereby the main generators are enabled to operate under fixed loads and normal voltage, while the

Fig. 125.—View in Battery Room in Large Central Station with End Cells in Distance.

variable portion of the requirements is entirely transferred to the booster.

The ability to reverse the polarity of the booster is of value for facilitating the discharge of the battery, for in case of an accident to the generator, or of sudden overload, when time was lacking to start an additional machine, the battery could be compelled to come to the rescue, and for a short time deliver a relatively large share of the current.

The arrangement shown in Fig. 123 would be classed under the manually controlled sort. It has valuable and sufficient qualifications for following the demands of an electric lighting plant, but for classes of service in which the fluctuations of load are sudden, frequent, and severe, as in railroad circuits, automatic control of the functions of the booster would be desirable. Such results have actually been secured and regulate the system to a degree almost marvelous. For this purpose, the booster is furnished with a series winding on its field-magnet, through which the entire current to the particular circuit to be controlled passes, but in the opposite direction to the current in the other or separately supplied winding. The result is a differential winding.

When there is no demand at all in the exterior circuit, this series coil is inert, and the excitation derived from the main winding prevails so as to give the booster its highest electromotive force, and the battery charges at the maximum rate. When current is demanded, it flows around the field of a booster, with the result of somewhat reducing the strength of field magnetism, whereby less current is driven through battery, but allowing a proper share to go to line. If a larger demand for current exists, the field of the booster may be entirely annulled, whereby battery may be rendered inert—neither receiving nor giving. When an extra heavy demand comes, the series coil preponderates, reverses the polarity of the booster, and thereby helps the battery to discharge, and to that extent relieves the generator. By proper adjustment of the series winding and of the field rheostat, the points at which the charge and discharge take place is quite under control, as desired; but with the adjustments once made, aside from following the degree of charge of the battery, no further attention need be paid to the apparatus.

A view of a booster arranged for work of this sort was given in Fig. 85, in the chapter on "Current Reorganizers."

Sometimes other special windings are employed on machines of this sort to accomplish particular ends, the case being a confirmation of the point already emphasized, that electrical engineering represents a highly specialized collection of machinery, each doing a certain kind of work, but quite unfitted for doing any other of equal value. The adjustment of means to particular ends is one of the conspicuous marvels of the art. To show in a graphical manner what are the demands upon an ordinary city electric lighting station, and just how a storage battery assists in preparing for that demand, and then in supplying it, a curve of the station output for a single day may be given, as in Fig. 124. The readings were taken from one midnight to the next, in early winter. In consequence of the drain on the battery from the preceding evening's use, and with recognition of the principle that it should not, for even an hour, remain empty, the charging began at once. In the particular case illustrated, the current was kept at about 2,500 amperes until the proper voltage and specific gravity was reached, necessitating the continuance until about 5 o'clock in the morning. Since the demand for current for other purposes was a minimum during that time of the night, it represented the most favorable opportunity for charging. From the diagram it appears that from this time until nearly 7 o'clock there was only a very small output from the station, the time being probably improved to shut down most of the apparatus for examination and preparation for the day's run. At 7 o'clock the starting of motors and lights in shops made a sharp rise in the load, continuing to rise until 8 o'clock, when the full load was on, and this remained fairly constant until noon. There was a marked cessation at this hour, and the load restored rather tardily, but shortly after 3 o'clock the rise was not only rapid, but extreme—quite beyond the ability of the generators to supply. The battery had been idle until this time, but now came to the support of the generators, and indeed carried fully as much load. All the available generators were probably started, supplying in all about 5,000 amperes, but the demand was for a total of nearly 10,000, an amount properly designated as the "peak" of the load.

After 6 o'clock in the afternoon the load fell off rapidly, and some of the generators were shut down, the battery continuing to supply some of the demand, until about 10:30, when the charging process again began at something over 2,000 amperes. Of course rather more energy has had to be put into the battery than was returned, for only about eighty per cent is recoverable, and the relative areas of the charge and the discharge portions of the diagram truthfully testify the fact.

Were it not for the storage battery, sufficient power in engines, boilers, and dynamos would have to be kept on hand, ready for this peak load, then after a short run, be shut down again, and remain a source of expense without earning revenue until the few hours offered on the next day. With the added opportunity of having batteries located not alone at the central station, but at various sub-stations within well-defined centers of distribution, far better regulation of voltage can be maintained than when the system is supplied directly from the generators.

Such cells as are used in large stations are heavy and expensive. Glass jars are not practicable in these sizes, hence recourse is had to wooden tanks, lined with sheet lead, with plates of glass standing edgewise to support the weight of the lead plates and to prevent them from coming in contact with the lining. The cells are usually located in basements, where sufficient foundation for the great weight is afforded. A view of a battery room in a New York station is given in Fig. 125. A portion of the main body of cells is in the foreground, and the numerous vertical copper bars seen in the distance are recognized as furnishing the double sets of end-cell connections belonging to the three-wire system typified in Fig. 122.

CONDITIONS OF SUCCESS WITH AEROPLANES.

SUGGESTIONS BY A PRACTICAL AERONAUT.

BY L. J. LESH.

There is probably no problem in engineering mechanics which boasts such a scarcity of reliable data as the new-found science of aviation. Countless experiments and calculations have established the art of hydrogen ballooning on a fairly stable mathematical basis, but the design of gasless or "heavier-than-air" flying machines still involves a dangerous amount of guesswork.

Aeronautical engineers who have had experience in the design of aeroplanes realize the inadequacy of the formulæ and tables at our disposal to cope with new developments, and we feel seriously hampered thereby in our ambition to work out original plans which do not permit of exact calculation and verification of principles before the machine is put into the air.

However, with a fair knowledge of the general principles of flight and the design of machines, a builder should be able to construct an aeroplane (employing a high factor of safety) and to carry on his experiments safely without going into the deeper mechanics of flight, which are rather complicated and had best be left to the scientists who are perfecting these formulæ and tables by means of laboratory experiments.

As this paper is to deal exclusively with aeroplanes, I will not consider other types of flyer such as the gyro-plane, helicopter, and ornithopter.

After constructing and testing many different types of aeroplane, experimenters have produced three general types of machine which can prove their ability to take to the air under favorable conditions and stay aloft until the motor gives out or an accident occurs to the wings or rudders. These types are the monoplane, invented by Lilienthal and reaching its highest development to date in the Bleriot and R. E. P. machines; the following-surface flyer invented by Prof. Langley and copied by Bleriot; the Chanute types (two-deck, three-deck, and multiple wing) invented by Octave Chanute, perfected in part by the Wright Brothers, and imitated by Santos Dumont and the Voisin Frères, constructors of the Delagrange and Farman flyers.

The monoplane flyer has met with considerable favor among designers because of its similarity to the soaring birds which give us daily proof that flying can be accomplished on wings of the monoplane plan. The simplicity of this type also makes it comparatively easy to calculate beforehand the exact values of the wings and the power required for propulsion, thus giving the engineer who adopts this design something of an advantage over the experimenter who plans a machine of the Langley or Chanute types.

The principal disadvantage of the single-plane flyer is its lack of inherent stability during flight, since it is quite out of the question to devise artificial surfaces which will duplicate the complicated balancing movements of the soaring bird's wing.

Experimenters have attempted to balance monoplanes by shifting weights and by various vertical and horizontal rudders, but these methods of control are seldom resorted to by the birds, and in adopting them for their machines, inventors have imitated Nature's design without following her excellent example as to principles of operation. In this connection it might be well to call attention to the fact that one experimenter at least attempted to build a machine that would duplicate the soaring of birds as he explained the phenomenon after thirty years of observation, but he did not live to realize his ambition.

This man was Louis Pierre Mouillard, a wonderfully patient and accurate observer, who was unfortunate, however, in his methods of experiment and finally became despondent through his failure to launch a machine which was probably quite capable of soaring had it been skillfully manipulated. He was enabled to carry on his work through the generosity of O. Chanute and it now seems that if he had adopted that excellent engineer's methods of experiment he would have excelled the performance of Lilienthal and probably equaled the flights of the Wright glider.

The monoplane in its simplest form, as devised by Lilienthal, was intended merely for experiments in gliding flight, and since the whole weight carried through the air was not very great, it was a comparatively simple matter for the aviator to balance the wings during wind gusts by shifting his weight. Such an apparatus, spreading some 200 square feet of supporting surface, can be made of wood, wire, and cloth so as to weigh about fifty pounds; but when the surfaces are enlarged and a motor added, the disturbing forces cannot be met by shifting the center of gravity and new controlling influences must be utilized to maintain the equilibrium.

If the main supporting surfaces are rigid and shaped to the plan, curvature, and attitude of the soaring or sailing birds (wings tilted upward at a dihedral angle as the buzzard or arched downward in the attitude of the sea gull), then the main disturbances to be overcome are, first, fore-and-aft oscillation resulting in dangerous downward plunges; second, lateral oscillation during changes in direction and velocity of the wind.

Fore-and-Aft Stability.—This problem may be solved by hinging the sustaining wings in such a way as to permit their flexing backward and forward, adjusting the center of pressure to the variations in velocity of the wind and to changes in the angle of incidence of the machine to the air current.

This is the way of the birds and it was adopted by Mouillard and later by Chanute, who utilized the principle to good effect in his multiple wing glider, but the device has never to my knowledge been tested on a motor-driven flyer. Present-day experimenters prefer to maintain fore-and-aft balance by means of horizontal rudders and shifting weights or merely by accelerating and retarding the motor. Any one of these methods might be sufficient for ordinary conditions but they are certainly inferior to the way of nature, which is positive under all conditions and has the advantage of automatic action which leaves the aviator free to attend to other things connected with the machine's management.

Lateral Stability.—The second problem constitutes the principal drawback to the development of aeroplanes whether they be of the monoplane, multi-plane, Langley, or Chanute type and as yet no satisfactory solution of the problem has ever been made public. Some few experimenters have made indifferent attempts to maintain lateral balance by means of some special attitude of the wings, shifting weights, or vertical keels, but the greater proportion of designers are either entirely ignorant of the importance of this feature or they purposely ignore it for reasons that reflect no credit on their inventive ability.

The writer made a careful study of the problem of lateral balance during experiments with ten different aeroplanes, but this work had to be supplemented by several months of concentrated theoretical investigation before a satisfactory plan was found.

Countless designs were drawn up and considered, but ly two of the systems provided an adequate solution the problem. The first of these inventions evolved rectly from a suggestion of Octave Chanute, who considered some of the plans and checked them in the ght of his wonderful analytical powers. It was greed, however, that this plan did not provide an ltogether satisfactory answer to the question and so new and absolutely unique system was tentatively resented as a last resort.

This plan seems to provide an adequate solution to he problem, but there being almost no reliable data pon which to base our calculations regarding it, I emain skeptical of its success at first trial, although he principles are perfectly sound and a few experiments will suffice to gather information for future use. As this invention is the subject of patents it will be mpossible to divulge the secret at present and my nly object in treating this phase of the problem is to how the importance of providing adequate apparatus or the maintenance of lateral equilibrium during variations in direction and velocity of the wind.

These disturbances are the direct result of changes n the position of the center of pressure of the supporting surfaces, this point being a rather variable quantity but generally tending toward the part of the surface which is receiving the most pressure.

Since the main trick in flying consists in keeping he centers of pressure and gravity coincident, it is evident that the designer has his choice of two methods of procedure in balancing, for he must either make the center of gravity follow the center of pressure or the center of pressure must be constantly shifted to coincide with the center of gravity.

In small machines of the Lilienthal and Chanute pattern it is quite possible to consider the center of gravity as a variable but in the heavier dynamic apparatus it is necessary to make the center of gravity constant and the center of pressure variable, depending on some system of compensating surfaces to effect the changes in the position of the center of pressure.

Some Features of Design.—Much might be written regarding the efficiency of various wing attitudes (shape of wing when viewed from front) and the importance of this feature in the design cannot be overestimated. Of the many "attitudes" which have been demonstrated theoretically and experimentally, there are two which we recognize as distinct types. The first of these is the dihedral angle in which the wings slope upward from the center to the extremities and the second is the "gull" or depressed-wing attitude, so named after the position for sailing flight assumed by the sea birds.

The dihedral angle was probably first suggested by the soaring of the buzzards and other land birds, but we find it hard to place the responsibility for its introduction to aeronautics on any one experimenter or theorist. A flyer designed with the dihedral angle is well suited to flight in a calm or light wind, but proves a treacherous proposition under any other circumstances. Its principle of operation is that the wing which becomes depressed will receive less pressure than the wing which tilts upward and that these forces will constitute a dynamic couple tending to automatically maintain equilibrium.

This has been found to work out satisfactorily in light winds and when the current blows directly toward the machine, but unfortunately these conditions do not obtain on many occasions and it is found that a flyer utilizing the dihedral angle almost invariably capsizes when struck by oblique currents. This is easily explained, for when the wind strikes the upraised wing obliquely to the line of flight, the pressure on that wing increases tremendously, owing to the wing being placed at a more favorable angle of lift than when the wind strikes directly in front, and thus under most conditions, instead of acting as a force tending to right the machine, the dihedral attitude proves quite fatal to its stability.

The gull or depressed-wing attitude, on the other hand, is found to work equally well in wind or calm, and if the flyer is well balanced, side gusts may strike the wings without producing any disturbance other than a slight depression of the side of the machine nearest the wind.

This favorable result is caused by the wind striking the tip of the wing from above instead of below and counteracting the tendency of the wing nearest to the wind to lift unduly but yet not affecting the efficiency of the aeroplane as a whole. While this feature in the design will assure good inherent lateral stability, yet it must be remembered that exceptional conditions are liable to arise during flight in high or cyclonic winds and that adequate provision must be made to meet all emergencies.

Thus it will be found that most air currents close to the ground are rotating around horizontal axes and also more or less about a vertical axis, so that instead of a steady current the flyer must make its way through a veritable maelstrom which affects the fore-and-aft and lateral stability of the flyer in a most peculiar manner.

A very ingenious experimenter, Mr. G. A. Spratt, has investigated these phenomena and demonstrated quite clearly that "curvature" of the aeroplanes must be used as a relative term, since a plane surface flying in a rotating wind and a curved surface flying in a straight wind are operating under approximately the same conditions and call for similar propelling and balancing forces.

This hypothesis assists us materially in propounding a more rational theory of soaring and sailing flight, and the difference in curvature of wing noticed in birds which fly high in air and those which sail close to the ground (or to the surface of water) is no longer a mystery. It is now obvious that vultures which fly in the steady upper currents require deeply curved wings, while the sea birds which sail in the turbulent surface winds can extract more power from the wind if the wings are less deeply curved or are very nearly plane surfaces.

As was stated at the beginning of this paper, aeroplane designing embodies a dangerous amount of guesswork, and the various theories and features in design presented here are not yet permanently established, although they form the best working basis at our disposal.

Formulæ and Tables.—After mastering the theory and general principles of aviation, the experimenter will undertake to apply the various tables and formulæ to the calculation of aeroplane efficiency, and it might be well to outline the best course of action in carrying out this part of the work.

The standard literature on aeronautics is not overloaded with reliable tables and formulæ, but it will be found that the data published by Chanute, Langley, and Lilienthal will enable the engineer to arrive at fairly accurate results.

An estimate of the speed which will be required for support in the air may be arrived at by computing the total lift which will be obtained with the surfaces at a favorable angle of attack (say 7 deg.) and at a speed which will allow a fair margin of lift over the total pre-estimated weight of the machine and operator.

After estimating the speed required for support, the engineer may then arrive at the power required for propulsion by computing the total resistance of the framing at the given speed and adding to this the horizontal component of pressure or drift of the aeroplanes. The lift and drift of aeroplanes or of plane surfaces may be estimated by the Chanute tables for planes or the Lilienthal table of coefficients for curved surfaces. These tables will be found under the head of "Aeronautics" in the Encyclopedia Britannica.

Having estimated the weight of an aeroplane and operator without the engine, the designer seeks a motor which will deliver the maximum of power for the given limit of weight which the machine will lift and if the thrust developed by this motor shows a fair margin over the resistances to be overcome at the speed of sustentation he will know that his machine is at least capable of supporting itself in flight.

Formula for "Effective Area."—Although the data now accessible to aeroplane designers may appear at first to be quite complete and fairly reliable, yet a more careful study of the matter reveals the true intricacy of the problem and several factors come to light which are as yet unknown quantities.

The Spratt theory, although very valuable as far as it goes, does not go far enough, and there are other similar phenomena of atmospheric currents which remain something of a mystery.

While there are reliable tables and formulæ for computing the lift and drift of surfaces at various angles of incidence, yet these tables only purport to obtain with surfaces of a given shape, and it is a well-known fact that aeroplanes having the same area but being of different shapes will differ greatly in efficiency.

Thus, a plane 5 feet long and 1 foot wide will have 5 square feet of surface, but if it be presented to the wind with the entering edge of a foot, it will be vastly less efficient than if presented with the entering edges of 5 feet.

This is an established fact and since every designer must take it into consideration in selecting the shape of his surfaces, it might be well to formulate the facts and derive a new coefficient to be used in determining the effective area of rectangular aeroplane shapes. This "effective area" must then be used instead of the real surface area of the wings in computing the lift and drift.

The following empirical formula will be found to accord fairly well with practical results and to provide a necessary link in the chain of calculation forged by aeronautical engineers. Other formulæ have been proposed by Goupil and Soreau as deduced from Prof. Langley's experiments:

Let L = length of surface,
W = width of surface,
$M = L - W$,
then A = effective area.

L = length of entering edge or the dimension of the surface in the direction at right angles to the line of motion.

$$\frac{W^2}{2} + \frac{W}{2} + MW = A = \text{effective area.}$$

A HOME-MADE THERMOMETER.

By A. Heaton.

It would seem at first thought that meteorology is a subject which has no connection with the generation or conservation of steam energy, but on reflection it will be seen that natural thermic and barometric conditions either assist or retard those artificially produced in a measure proportional to their extreme changes. For illustration, consider the vast sums which are paid out for more or less non-conductive substances to counteract those external effects. Again, if a locomotive will haul a given train in August with a certain amount of coal, we do not expect it to haul the same train with the same quantity of coal in January.

There are also many engines at the sea level which maintain a vacuum of 27 inches, and there is a Westinghouse-Parsons turbine in my city which shows as high as 29¼ inches on a mercury vacuum gage; on days when the barometer is high it will go as high as 29¾; and a high vacuum in a turbine installation represents money, lots of it.

But because these things are done near the sea level it does not follow that they could be also done at the summit of the Himalayas, nor even up among the Rocky Mountains, for, approximately, water boils at 1 deg. F. less for every 596 additional feet of altitude, so that at the summit of the Himalayas, the highest attainable vacuum would be less than 11 inches.

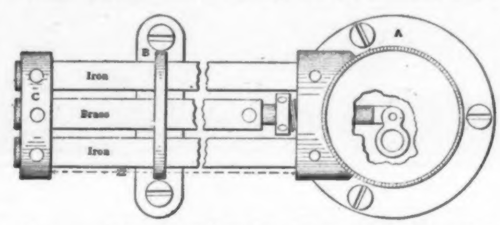


Fig. 1.—CONSTRUCTION OF MAXIMUM AND MINIMUM REGISTERING THERMOMETER.

The maximum and minimum registering thermometer here illustrated consists of a circular box A, Fig. 1, 1½ inches diameter and ⅝ inch deep, with a knurled screw-cap and a flange for screwing the device to the north side of a building. Into a boss on the box are screwed or pinned two 22-foot lengths of iron ¼-inch gas pipe which run through a series of guide supports B and are made fast in the cross tail-piece C. A 22-foot length of brass ⅜-inch pipe is made fast in the tail-piece between the two iron pipes, but runs free at the other end, entering with a reduced diameter through a dust-proof stuffing-box; it is attached to a 5/16-inch crank on a ⅜-inch shaft which goes through to the inside of the building, and it carries a pointer 18 inches long, which extends downward to a graduated brass arc, Fig. 2. On this arc are two slides which the pointer pushes along and leaves at the extreme limits of its travel.

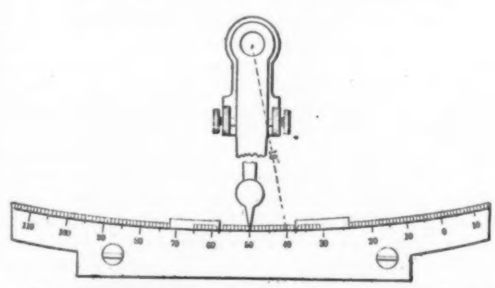


Fig. 2.—POINTER AND GRADUATED BRASS ARC OF THERMOMETER.

With this thermometer it is not necessary to go outside to get the outside record, but simply take the record from the slides once in 24 hours and push them back against the pointer for the next day's record. With metals of average density, the differential expansion between brass and iron will give with 22-foot tubes and a 5/16 × 18-inch indicator an approximate travel on the dial of 1/20 inch per deg. F., but as all metals vary in density, it is safer to calibrate from a reliable mercury thermometer.—Power.

Artificial Wood Substance for Plastic Decorations.—The sawdust of soft woods is boiled with a solution of glue and water glass, and to the resultant mass so much sawdust added and thoroughly mixed by kneading as to produce a dough-like mass. This is pressed between iron plates, dried, and ground. Colors such as English red, cinnabar, etc., may be mixed with it at an earlier stage.

THE OLYMPIC GAMES OF ANCIENT GREECE.

BY WATKISS LLOYD.

A RESTORATION OF OLYMPIA.

Olympia lies a few miles from the sea in the northwest corner of the Morea. Half a century ago its very site had almost been forgotten, so completely had time, earthquakes, and the yet more barbarous hand of man done their work. But in the years 1875-80 the whole of the sacred precinct was excavated by the German Archæological Society at the expense of the German government. The illustration shows a reconstruction of the sanctuary as it must have appeared in the second century A. D. In its crowd of temples, monuments, and statues could be traced the history of Greece for over a thousand years. In the forepart stands the Temple of Zeus, erected in the fifth century, shortly after the Persian war.

THE five contests which constituted the Pentathlon of the ancient Greeks were leaping—apparently a standing jump—spear throwing, discus hurling, running, wrestling. The trials took place in the order of this enumeration. The leap was taken with the help—if, indeed, help—of the halteres, a sort of dumb-bells held in the hands, and swung backward and forward before the leap. University athletics give no assistance, it appears, to judging of their value. It must have been marvelous if it enabled Phayllus of Croton to leap fifty-five feet, and Chionis fifty-two. There is a serious difference somewhere between such achievements and modern records, whether it is to be referred to the actual feats accomplished—the standard foot-rule employed—or brag. The discus was hurled by an underhand cast, and distance only was considered; as successive throws even from the same standing place might not be in a direct line, a cross line would be required—a scratch—to decide direct distance, and this explains a phrase which occurs also in reference to the comparative distances of leaps. In the case of spear throwing, not distance alone, as in the trial with the discus, but closeness to the mark was also taken into account. Two passages at least, if not three, can be adduced from Pindar's Epinician Odes, the best authority possible on such a question, any one of which might be accepted as decisive. In his eleventh Olympic Ode he brings the victory obtained by hitting the mark—scopus—with the spear into immediate contrast with that of the discus thrower who covers simple distance.

"THE WRESTLERS" FROM THE UFFIZZI GALLERY GROUP AT FLORENCE.

The well-known Uffizzi group of wrestlers represents not wrestling proper but the pankration. Ground wrestling was not allowed in wrestling proper, but was allowed in the pankration, a sort of scientific rough-and-tumble which combined wrestling, boxing, and even kicking. The group though a late work is full of vigor and free from exaggeration.

"By Phrastor aimed, the javelin flew
Right to his mark. Eniceus threw
Over all, with skill adroit
In measured length, the massy quoit,
Wheeling it in his hand about."

In the last lines of the ninth Nemean Ode throwing the lance at a mark is assumed as a natural and familiar metaphor.

Running and wrestling, the two most exhausting exercises, were appropriately placed after the others, and of these two wrestling, as the severest, was last of all. Of course there is a diversity of opinion on the subject. When the scheme of the pentathlon was once completed, it seems meaningless unless the true essence of it was to test a true balance of well-developed forces; and this, in fact, was the value which the ancients assigned to the training which prepared for it and gained for it the approval of physicians, who did not fail to denounce the partial development of the frame which resulted from training for a single exercise as vehemently as any modern opponent of cram inveighs against the intellectual forcing that "dims the eyes and stuffs the head," and for the sake of a class—

"Full in the midst of Euclid dips at once
And petrifies a genius to a dunce."

The evidence is conclusive for the fact that three victories out of the five contests were required for final success; and then we are involved in what appears a difficulty that requires explanation. If the same man won in the first three easier contests, there would be an end of the matter, and the pentathlon as such would be deprived of what was most characteristic, and its purpose frustrated. And must not this have been, under such conditions, a frequent or even a usual event? Trainers of the renown of Pindar's Melesigs were certainly as wise in their generation as crammers in our own, and would not trouble themselves or their men with labor that might be spared for any use it would be at the examination of the contest.

It is perhaps of less real interest to inquire how the ancients settled these matters, considering the paucity of evidence, than to endeavor to evolve upon rational considerations how they might or ought to be arranged. The mere archæological student may become bewildered about the Olympic custom.

But when foiled in an endeavor to reconcile or understand the scattered and obscure allusions of the ancients, we may be more hopeful in dealing with the problem if we attempt to construct a scheme of a pentathlon on the same independent principles. It then becomes evident that what is required is to secure the prize for that man who, with one or more victories in the severer tests, can combine a test victory, or more than one, in contests of contrasted character. From this point of view, victory in wrestling, as one of the three at least out of five, would be indispensable; and, therefore, those only would be admitted to the trial of wrestling in conclusion who had already been victors in at least two other contests, while victors in even more than two would still be bound to this last trial. The other contests fall into pairs. Overhand and underhand hurling with discus or spear are exercises of strength of arm, and in one case with requirement of the faculty of aim; and then the standing jump and the trial of speed test the vigor of the lower limbs in no less diverse action. It would seem not unfair to require that of the two qualifying

A RACING CHARIOT FROM THE VATICAN COLLECTION, ROME.

Chariot racing was a favorite sport of both Greeks and Romans. The Greek chariot was a much lighter vehicle than the Roman one represented in our illustration. In the four-horse chariot race the charioteer stood, but in the two-horse race he sat on a small raised box not unlike that of an American "spider."

"THE BOXER" AT THE VATICAN, ROME.

It is no Greek work but the work of the Italian sculptor, Canova, representing a well-known fight at the Nemean games between two boxers, Creugas and Damoxenus. When neither could win the victory they agreed to hit one another in turn without guarding. Creugas delivered the first blow on Damoxenus's head, and the latter next drove his open hand with such force into his opponent's ribs as to pierce his side and kill him. The brutality of the conception is quite foreign to Greek art, but the artist has reproduced the ancient form of boxing.

victories one must be from each of these pairs. So we should have for participation in the final trial of wrestling, two victors, namely, one in—

Discus and Jumping
or in Discus and Running
and one in Javelin and Jumping
or in Javelin and Running } Wrestling.

THE SACRED CITY OF OLYMPIA—WHERE THE ORIGINAL GREEK GAMES WERE CELEBRATED—AS IT NOW IS.

The raised mass of ruins to the right is the great Temple of Zeus and the wooded knoll behind was dedicated to Cronos.

Of course a third victory might be obtained by one competitor in these primary contests:

Discus, Javelin, and Jumping
or Discus, Javelin, and Running
Jumping, Javelin, and Running
or Jumping, Discus, and Running } Wrestling.

The last series need scarcely be taken into account, and still less the possibility of a fourth victory; an athlete who had gained two of the preliminary prizes, and who knew that he would not better himself by gaining a third, or even a fourth, would be careful, unless he had the greatest confidence in his powers, rightly or wrongly, not to exhaust by useless exertions the strength which would be taxed to its utmost in the decisive contest of wrestling.

At the same time the victor in any two of the preliminary four, combined with success in wrestling, would amply certify a combination of power of the nature proposed to be encouraged by the pentathlon.

If any competitor were victor in three out of the first four contests, his competitor in wrestling could only have gained the other prize, and thus, if successful at last, would only count two victories. Here we are again involved in a difficulty, for we should have the liability for one man to spare himself any exertion beyond what would secure one of the first four prizes, in order to be fresh for the decisive wrestling.

To meet this, it becomes a necessity to reckon as winners both the first and second men in the first four contests. Some of these winners might be excluded from wrestling by only having secured a place once either as first or second. But taking the extreme case, there would be four qualified by double victories thus understood, the first and second men in the pair of contests including discus, and the first and second in the pair including javelin throwing. That is, eight places admit of being distributed in pairs among four men at most; or they might be distributed between three men, so that no one had less than a pair, though either one or two might have more; or between two men in any proportion, so long as neither had less than two.

If only two came out qualified to enter for wrestling, there would, of course, be no difficulty; if four were qualified, they would cast lots for pairs in the first instance, and then the victors in each pair would wrestle for the final prize.

In case three were qualified, neither more nor less, it would be necessary to cast lots for the advantage of sitting out to wrestle with whichever of the other pair might be victor. The only scheme that presents itself for equalizing chances in some degree would be for C to be matched not only with A, the victor of the first pair, but, if he were winner, then with B, the vanquished in the first match. Each then might have to contend with two adversaries; but, nevertheless, unfairness would still remain, as A would be at the comparative disadvantage of having to engage two men in succession unexhausted by a previous encounter.

Now the Greeks—to compare their practice in this point first—had certainly a scheme for settling the difficulty of a prize for wrestling when there were three competitors. The man who drew a "bye" (this seems to be the technical term) was called the ephedrus—literally one who lies by.

The classical citations are also decisive, that three victories were necessary to constitute a victor in the pentathlon as such, and it is most important to note "that in every case where we hear of wrestling as part of a pentathlic contest, the winner in the wrestling is victor in the whole."

Again, there is strong presumptive evidence in favor of a second place in the four secondary contests being reckoned provisionally as a victory, to count as one if followed up by decisive victory in the greatest contest of all. Philostratus gives a story of the institution of the pentathlon by the Argonauts at Lemnos, and may be assumed to have told his story consistently with established usages. Telamon threw the discus best, and Lynceus the spear; that this victory is assigned to a hero of supernatural sharpness of sight is another proof that accurate aim was a requirement. One of the sons of Boreas ran the farthest and the other leaped the farthest—very naturally, as they are represented winged. None, therefore, gained a double victory; but Peleus, who was first in none of these contests, but second in every one, gained the prize in wrestling, and so was the first pentathlic victor.

Ancient authority fails to support me in requiring that the two qualifying victories out of the first four should be of contrasted character. The seer Tisamenus was victorious in running and leaping, but was overthrown in wrestling by Hieronymus, who as first in

THROWING THE JAVELIN AT A TARGET FROM HORSEBACK.

At Olympia the only competition with the javelin was one for distance, but at the Panathenaic festival at Athens there was an event in which mounted youths threw javelins at a target as they galloped past. The prizes at these sports were jars of olive oil, and it is from one of these prize vases that the above illustration is taken. One rider has already cast his javelin and it is fixed near the center of the target.

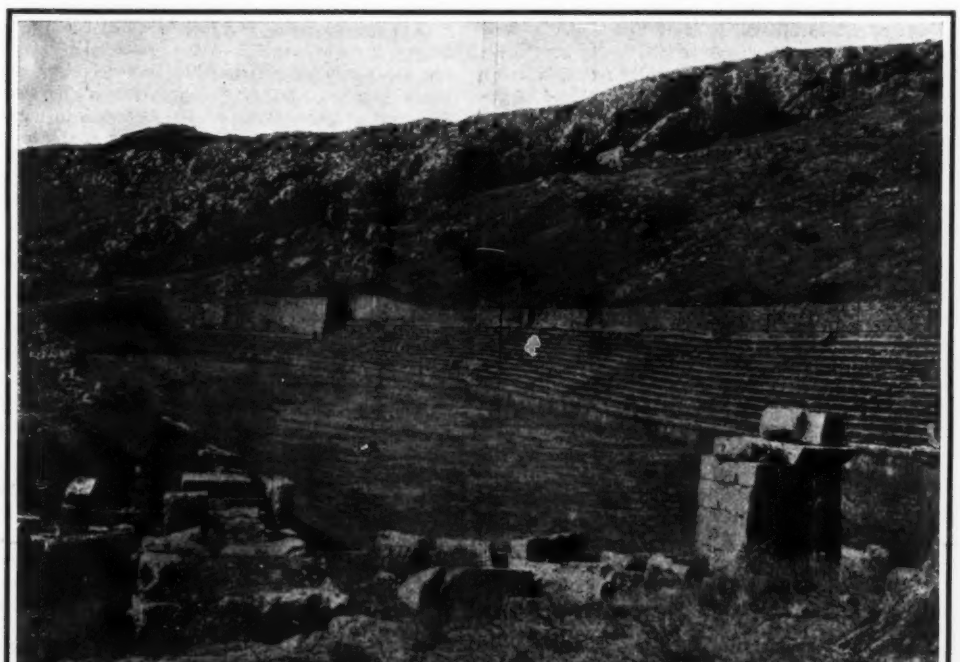
spear and discus throwing scarcely evinced such true pentathlic prowess as if he had interchanged one of his other victories. A pentathlic victory must, of course, be more or less honorable, according to the standard of distinction of the victories which secured it in conjunction with the indispensable wrestling feat. Peculiarly honorable would be those cases in which more than the necessary two preliminary victories had been gained. Indeed, by the time the last contest was reached, the competitors might be ranked according to the order of their achievements up to that point. In the case of the Lemnian pentathlon no competitor has three victories in the strictest sense, and Peleus is only victor upon a valuation of total marks. Unless some principle of this kind was adopted it might constantly occur that no one competitor secured three first places, and in consequence the pentathlic prize could not be assigned at all. There is evidence that in the Olympic chariot race even a fourth place was called a victory. Thucydides states that in the games of the ninetieth Olympiad, Alcibiades conquered with his chariots as first, second, and fourth; a fragment of the ode which Euripides wrote on the occasion gives the victories as first, second, and third, instead of fourth, a difference which is explainable. A Lacedæmonian excluded from competing had entered his chariot as Bœotian, but could not resist rushing upon the course to crown his driver; he was driven back with blows, and the disallowance of his place moved up the fourth of Alcibiades, which perhaps might not otherwise have counted as a victory at all.

Surely it is desirable that a principle akin to that of the ancient pentathlon should be introduced into modern athletic sports, and the highest prizes given to the winners of double events at least of such contrasted character as to prove that perfection in one exercise has not been obtained at the cost of utter incapacitation for any other.

The assumption that a victory in the final wrestling was indispensable for the pentathlic victor may explain why it is not specially exhibited on some monuments that seem commemorative of success in this contest. An ancient discus is engraved with a leaper on one side, a javelin thrower on the other, "the discus itself, by a pleasing conceit, filling up the third place, and thus becoming a complete symbol of the pentathlon of success, in which contest it was doubtless a votive memorial." It is tempting, no doubt, to recognize here the three victories that would give a majority out of five; but to do so would, as it has appeared, deprive the pentathlic scheme of justification for existence. It would cease to be a test of muscular strength, developed proportionately throughout the frame, and combined with dexterity and skill.

The conclusions which are here deduced as to the regulation of the pentathlon from simple consideration of its leading purpose appear to be coincident for the most part with those arrived at by Dr. Pinder in a work of length and learning ("Der Fünfkampf der Hellenen"). The accompanying illustrations are reproduced from the Sphere.

Cork-like Mass (G. Hagemann).—Comminuted cork is saturated with a solution of nitrated cellulose (gun cotton) in ether and alcohol and left in the molds imparting the desired form under pressure until the larger portion of the solvent is evaporated and on opening the mold the mass retains its shape, which is the case of small objects takes from 4 to 6 days. The product, known as "suberite," serves as a substitute for cork.



A TYPICAL GREEK STADIUM. THE TIERS OF SEATS OF THE SPORTS ARENA AT DELPHI AS IT NOW APPEARS.

The stadium at Delphi recently excavated by the French is the best preserved and its situation the most romantic of all Greek stadia, being constructed on the steep rocky slope that overlooks Apollo's sanctuary. Like that at Olympia it consists of a straight narrow course some 200 yards long, but unlike Olympia it has at the western end a semicircular theater which was used for boxing, wrestling, and such events. To the right of the picture can be seen the stone slabs which marked the starting line. A similar row of slabs existed at the other end. Each slab has two parallel grooves cut in it, apparently to mark the position of the runner's feet. Between the slabs are square sockets for posts which it is tempting to suppose were used for roping the course, though of this we have no proof.

PREHISTORIC MAN.—I.*

A REVIEW OF MODERN THEORIES AND DISCOVERIES.

BY W. F. STANLEY, F.G.S., F.R.ANT.SOC.

There is no doubt that in the nature of man there is a profound interest in looking into the history of the past. In our ancient buildings we possess both the charm of beauty and of antiquity, and the same in degree in ancient armor, weapons, coin, statuary, and pictures, for which we erect our museums. In the British Museum we have perhaps the finest collection of antiquities in the world, in which we may trace the works of man rising from a low stage to great excellence. In art, which is always imitative of nature, we may in the past possibly have attained our greatest height, for we have nothing at present that exceeds the beauty of the statuary of Praxiteles, or of the Grecian orders of architecture. Still, we can always find that there is evidence of a *previous* to this in every country wherein man's work was of a much lower quality, and if we continue our observation by research to the most remote past, we arrive at the evidences of a period when man's highest art appears to have been to crack flint rudely to shape, to form his tools and weapons. Formerly, in excavating ancient monuments in Egypt, Babylon, Nineveh, Palestine, Greece, and other countries, we dug down to the floor line of the buildings only. In modern excavations the digging has generally been taken down to the bottom of the foundations, or lower. In nearly all cases we have found evidence of earlier buildings on the same spot, which were of very rude workmanship. Often the work found extends in periods far into prehistoric times, where we find that the tools used in the work were only rudely-worked pieces of flint that were left broken when used up. So that the superstructures that we admire are, relatively to the remote past, but modern works. If we estimate, in another direction, the antiquity of man, we find that his presence and his remains are spread over nearly the entire habitable parts of the world. This we can but conceive must have taken an immense period of time, as man's power of locomotion, even within historical time, was very limited. Formerly he had no roads to travel along, and his boats were only canoes cut out of trunks of trees, or at least frail structures made of skin that could only sail slowly along the coasts. How oceans were crossed and the human race spread over the world will remain forever a mystery; but at best it must have taken so long a period of time that it is beyond our powers of computation. If we attempt further to estimate time for the variations of the family of mankind, as we find it at present, we must allow a great period to bring this about. We know that we vary slightly from each other, even in the present assembly; but between ourselves and the negro, for instance—who is by no means of the lowest type—there is great variation. Nevertheless we are structurally alike; therefore, we feel certain that we are derived from a single stock. If this change occurred through slight variations, it must have taken a long period. The negro depicted on the walls of Thebes 3,000 years ago varies but very slightly from his living representative of to-day. Being fully convinced of the great antiquity of man, one direction that science has taken is to discover what changes may have occurred within the period of which we possess evidences of man being upon the earth. For this we must trespass upon the realms of surface geology. In a popular lecture I think it best to be very rudimentary on this part of the subject, so that I will try to explain how it is that we have reference to the past beyond history, traditions, and such evidences as I have mentioned. This we may attain by the study of the objects of man's early workmanship, which remain, under certain conditions, buried by natural causes near the surface of the earth. Of which conditions I may offer some details. By the grand order of nature, which appears to be designed for the delight of mankind, the earth is covered with hills and dales, mountains, rivers, and plains, with a surrounding ocean, which places all parts of the world in communication. What a poor dull place the world would be if it were but a flat plane, and incidentally to this, we may find through science how little we should really know of the world's early history. We live here among the Surrey hills, and by geology we can find inferences how these hills were created, from which I hope to show hereafter how they are related to the time of man's earliest existence upon them. If I were to dig a deep hole upon the spot upon which I now stand, I know that I should pass through a stratum of clay of over 100 feet in thickness. I can easily verify what this clay is. It is simply mud that has been slowly deposited from the river which flowed over this spot. I conclude thus in that I can find in the clay many species of fresh-water shells that are still in our rivers, also numerous scraps of decayed wood and reeds, occasionally leaves and fruit, as, for instance, dates, which have been found in great numbers at the Isle of Sheppey, and there are many other indications of its past history. If I dig down at Thornton Heath I find the subsoil composed of gravel, formed of flints exactly similar to those found in the chalk at Purley. Therefore I conclude that they were washed out from the chalk cliffs near. From this I have evidence that these cliffs once formed the banks of a great rapid river that flowed through Croydon. These gravels are found everywhere above the clay, so that I know they must be more recent than the clay. If I go to Purley Oaks I find that the ancient chalk cliffs break off abruptly toward Croydon and cut off the lines of stratification, so that these cliffs evidently at one time extended over Croydon and Thornton Heath. Further, we find in the gravels not only the same forms of flint, but the same fossils as at Purley. If I trace the chalk by digging wells toward London, I find that it everywhere underlies the clay, and I know, therefore, that it must be older than the clay. But the chalk downs of Purley are now much higher than the clay or the gravel. How is this brought about? I will try to give the reason. We may see hereafter how this affects our knowledge of the period of man's early appearance here by his work. By going deep into the earth we everywhere find increase of temperature of about 1 deg. Fahrenheit for every 70 feet, so that we are limited in all mines to the depth man can work. We assume this rise of temperature to continue to greater depths; we know also that rocks become liquid at a high temperature, as we find melted rocks flow in lavas from our volcanoes. We may therefore infer that the entire land floats upon a hot liquid or semi-liquid, magma, as it is termed, which is of greater specific gravity than the surface rocks, as sand floats on mercury. This makes all the land surface float, as it were, unstable in degree, and it accounts for the fact that hills are raised and valleys are sunk by the movement or tipping of the earth's surface. Accepting this fact, we may assert, as regards our chalk hills, that they were formed at the bottom of a deep sea. We further conclude thus in that we find by the microscope that the chalk is almost entirely composed of similar minute fossils to those found at the present time in the depths of the Atlantic, although they now rest here so much above our ancient river valleys. With regard to man, none of his works have been found below the gravel which rests above the clay, nor in any case except within the surface strata, which we know to be, geologically speaking, quite recent. So that we may take the conditions of the surface, other than gravels I have depicted of this district, exceeds the limits of the period of man's existence on the earth. The highest animal remains found in strata contemporary with our clay is the ape, some reference to which I will mention later. In a lecture I had the pleasure of giving to our Athenæum in 1905, upon the Diplodocus, an ancient lizard 170 feet long, of which a cast of the skeleton had recently been given by Mr. Carnegie to our British Museum, I described the smallness of the brain of the animals found in the lias strata, in which this large fossil was found. As we rise higher in strata above the lias we find by fossils that the brain of animals has constantly increased in time. It appears that the struggle for existence from this early period has been uniformly between the bodily strength and protective structure of the animal against the amount of brain power the particular animal possessed. This brain power appears to have gained the victory, to the extermination of the merely bodily protected animals. This is carried forward in time, through very slight variation of species, until we come to the advent of the highly-organized primates, the apes, and finally to man, who does not only reign supreme, but the higher races of man have constantly, as we find by history, exterminated the lower. This is particularly evident in our own race in relation to our colonies. The remains of man, or rather, of the flint implements that he used, come into evidence everywhere, with the river gravels and superficial river muds, or brick earths, as we now term them. Quite recently some bones of the early elephant (*Elephas primigenius*) were dug out at Thornton Heath, and some of the bones of a young rhinoceros at Mitcham, now to be seen in a case in the town library. I have here a mammoth tooth which I dug out of the superficial brick earth at Erith. We find, also, contemporary with the *Elephas primigenius*, the bones and teeth of the rhinoceros, hippopotamus, lion, cave bear, and hyena. So that we know that at a certain period these animals inhabited this country. We have also evidence that man, or a very intelligent animal, as I shall show hereafter, who was able to make flint implements for attack of these animals, was also in existence. The earliest notice of man in connection with the elephant (*Elephas primigenius*) was the finding of an elephant's tusk in connection with a heavy flint ax, by which the elephant was probably killed, at a depth of nearly 30 feet in the gravel, in digging a well in Gray's Inn in 1715, nearly two hundred years ago. This discovery raised a great discussion at the time, one argument being held that the elephant must have been one that had escaped, and that it was killed by tying a heavy chipped flint upon the end of a pole. During the last century, and at present, flint implements were and are frequently found in connection with remains of the elephant, mammoth, cave bear, and other extinct animals; so that it is no longer a dispute in science that man and these extinct animals were living together here at an early period. We may now follow the particular directions in which the work and remains of early man have been found. These are principally in old river beaches, such as the Croydon gravels, in caves, peat-bogs, refuse heaps, graves, and under ancient buildings. The early remains are commonly flint implements, bone tools, combs and sherds of hand-made pottery. It is usual to fix four prehistoric periods. Two of these in what is termed the Stone age, which divided into (1) the Paleolithic (the oldest), (2) the Neolithic (the newer stone age), (3) the Bronze age, and (4) the Iron age (in which we are now living). These terms are quite arbitrary, and only relate to the conditions of man in any single country wherein he has progressed from barbarity to civilization. In Central Africa, and in many of the South Sea Islands, as also in Greenland, man is still in a state nearly the equivalent to the early Stone age in Europe—that is, he uses chipped stones for weapons and tools. Generally in Europe the remains of early man are found under similar conditions to those of Great Britain. Therefore I will, for the most part, follow our local evidences, commencing with some of our ancient gravels, or, as they are termed, our ancient river beaches.

In the first place, for our consideration, we know that a river is always bringing mud down to the sea, and it follows that it must carry away the banks from which the mud is derived. If these banks are of chalk, the water undermines and dissolves the chalk and washes it away, particularly during floods. It leaves the insoluble heavy flints upon the foreshore. The chalk itself wears away also by rain, wind, and frost, and leaves the less perishable flints. No natural river flows in a straight course. The current is generally zig-zag, from side to side. Thus, a current may undermine and wear away a chalk cliff at its base and again cut in shoreward, so that it leaves, by accumulations, a wide band of fallen flints, sometimes even an island. This is probably the condition that prevailed at Croydon when its gravels were formed. If the strength of the current of the river subsides, then the river bank finally wears away into the distance on the land. The process of denudation of chalk cliffs by water may be seen near Margate and elsewhere, where a broad foreshore of flints is formed, to be reduced afterward by the action of the waves into pebbles and sand, such as those of which we have geological evidence in our Shirley hills. River action is much slower than that of the sea, where we have beating waves. Therefore, our inland gravels took originally much longer to form than those of which we have a visible evidence upon our sea-shores, where we may watch the chalk cliffs breaking away. Nevertheless, we must conclude that the great river, which formerly cut its way through the ancient chalk hills of Croydon and Thornton Heath, was much more rapid than the Thames at present. This was possibly largely due to a greater rainfall at the period, a fact of which we have other evidence. Further, the North of England was mountainous, and for a large part covered with snow, so that the entire central parts of the country projected rivers toward the south. As regards the evidence of the presence of man during the formation of these early gravels, we do not find this great in Croydon, where flint implements, except chips of flint, are only occasionally found. On the other hand, in the south of Hampshire, implements and weapons have been found in great numbers, of which there is a fine collection in the Blackmore Museum at Salisbury. This, and much other evidence, shows that the earliest inhabitants of Great Britain united in districts or towns, which was no doubt necessary for human protection where powerful wild animals prevailed. In the gravels upon the banks of the Avon, from Christchurch to Salisbury, which rise to various heights, a great number of paleolithic flint implements have been found. A fine flint ax was found by Dr. Blackmore beneath the remains of a mammoth, at Fisherton, near Salisbury, by which the animal was

* A lecture given at the Stanley Athenæum.

probably killed. From the number of weapons in flint that have been found with the remains of the mammoth, rhinoceros, hippopotamus, and other extinct animals, it is thought to be probable that these animals were exterminated in this country by means of the flint weapons that are found so frequently near the fossil bones. At Hoxne, in Suffolk, so large a number of chipped flints were found that this district is supposed to have been a manufactory of flint implements. Many flint implements are found here fractured, which may have been caused by accidents in manufacture, so that they were abandoned by the workers at the time. The age of the gravel beaches in which weapons have been found is estimated in various ways. To form the gravels in the only way we know that they could have been formed, must necessarily be a very slow process. To form one foot of gravel at least 50 feet of chalk cliff must have been disintegrated, and the chalk washed and dissolved away. The remains of the work of man, accompanied with the bones of extinct animals, are often found 30 feet or more below the upper surface of the gravel. The average estimate of the past time necessary to form our river gravels varies from 50,000 to 200,000 years, by the calculation of our geologists. The time required for the formation depends upon the time it must take to erode the banks of the river where there are chalk cliffs, which, in itself, varies under different geological conditions and the amount of rainfall at the period when the gravels were forming. Perhaps we jump at the conclusion that the flint implements we find at an early period must have been formed by man, our conclusion being drawn from the fact that man, in a savage state at the present time, forms similar implements in various parts of the world, and possibly did so always. The early flint weapons I have mentioned are merely flints roughly brought to a point by hammering one stone against another, and it does not appear to me to greatly exceed the ordinary intelligence of some living animals to have done this—as, for instance, the marked intelligence of the beaver with which he builds his house of logs of wood, plasters it inside in the summer to keep out the cold in winter, and forms outer walls for protection from floods; or, for another instance, that of the higher apes, who fight with sticks and throw stones with great precision. When one of our regiments was fighting in Abyssinia the apes pelted the soldiers in a pass through the mountains with stones, with such vigor and precision that they had to retreat, and were unable to proceed until they had stormed the heights which commanded the pass against the monkeys upon it. Geologically, we know that the ape preceded man by a long time, and we do not know the state of the intelligence of the ape at this period. At any rate, the low grade of intelligence necessary to chip out the paleolithic flints does not appear to me to be necessarily human. In the paleolithic gravels I am not aware that any of the bones of man have been found, and the evidence of his existence at the time of their formation rests entirely upon rudely-chipped flint. It is thought that early man used flint almost entirely for his weapons, domestic purposes, and tools; that, before the use of metal, man used only flint flakes for dividing the flesh of animals, cutting out canoes for fishing, scraping the flesh off skins to make furs, and other domestic purposes where a sharp edge was required. Our present evidence proves that this is true.

In the floating up of the superficial rocks of limestone, or rather hard rock, by earthquake, or plutonic pressure, the surface rock is increased in superficial area. Therefore, in such rocks, being inelastic, cracks or chasms are necessarily opened. If the rising of the land happens to block a river or a stream, the water then flows through the crack that is open, that gives it the freest passage. If the current is rapid it washes out the crack and enlarges it into a cave. As the cave becomes partially filled with sediment it commonly forms a pool, where the limestone that dissolves out of the sides of the caves, by trickling down to the floor, commonly again deposits slowly on exposure to air in the cave, so that the cave, by these means, is widened out at the same time as the floor is raised. On the seashore, caves are formed by working out the softer parts of the rocks. In any case, where early caves have been formed, they have generally become the abodes of wild animals, or sometimes of man, whose remains upon the rising floor give us possibly the best index of time of his existence in the past. A great many limestone caves have been carefully examined in many parts of the world. One general order appears to rule in many. The limestone that forms at the bottom of the cave buries and consolidates the bones, tools, or mud upon the surface. As such caves give protection from the severity of the winter, and are often easy of defense from enemies by the smallness of the entry, they thus gave security to either animals or early man, who may at the time have gained possession. Beyond the deposit of limestone on the floors of caves, which is generally local, the animal or the man brings in the mud on his feet from the surrounding district, and *débris* falls from the roof, so that, under these conditions, the floor of the cave slowly rises until in some caves we have 20 feet or more of this accumulation. Where the cave is occupied for the time by the cave-bear, lion, or hyena, he brings in his prey to devour. The soft part of the bones of the animals that he brings in are all gnawed away, and the hard part and teeth only are left, which we find. These remains are generally mixed with the excrement of the animals. At the mouths of the caves there are often piles of stones, which indicates that the animals have at times been pelted back by man into their retreat in the cave. When man had occupied the cave we find remains of his flint tools, needles made out of fishbones for sewing skins together with strips of other skins, bones sawn at the ends to form combs, and other simple articles. We know of man's presence, particularly in that he always cracked the leg-bones of animals across to extract the marrow, and he commonly ground the splint-bone to the form of a spoon to extract it. In earlier times there is no evidence of the use of fire, although, still at an early period, we find layers of ashes in the caves to denote man's presence, and the evidence of some form of cooking, as shown by scorched bones. Man's food appears at this time to have been indifferent to species of animals, as we find the remains of all the animals that were present at the period. Of the cave that I have visited, and in which I have taken the greatest interest, I will offer some particulars. At Settle, in West Yorkshire, a cave in the mountain limestone has been named, since its research, "The Victoria Cave." Funds for its careful excavation and examination by our eminent geologists were provided by the British Association. This cave is about 1,450 feet above the sea and 900 feet above the river Ribble. It is sheltered north and east by the cliff, of which it forms a part. Thus it was well protected for the safety of its occupiers. In its excavation near the top surface of the floor of the cave, a dark layer of charcoal was found, with burned bones of our present domestic animals, sherds of pottery, coins of Roman emperors, and articles of use and ornament, and bone, ivory, bronze, and enamel. In places the British Roman layer was 2 feet in thickness. Below this, and passing up into it, was a layer of mixed earth, 5 or 6 feet thick, in which were found two perfect stone implements, one of ordinary chipped flint and the other a small adz of a hard rock similar to those still used by the South Sea Islanders. There were also many cracked and hacked bones found, giving evidence of the presence of man. In continuing the excavation for 19 feet below the Roman layer, what was distinguished as the lower cave earth was reached. This contained many large pebbles (throwing stones), and remains of the hyena, fox, bear, elephant, rhinoceros, hippopotamus, bison, and red deer. Among these remains two artificially-hacked bones of the goat and one bone of a man was found. Over this human bone there has been a great discussion among our naturalists as to whether it is human. The bone is a fibula, or small bone of the leg. It is short for a human bone, and very thick—after the style of a gorilla bone. Some light appears to have been thrown upon the subject by finding, in several caves in Belgium, many very thick limb-bones, undoubtedly human. In a cave at Mentone, in the South of France, the remains of a paleolithic man, who had been crushed by the fall of a large stone from the roof, were found. The fibula of this man was nearly as thick as that found at Settle, which has, perhaps, settled the discussion. It is difficult to imagine the presence of man at 19 feet in depth in the Settle case, unless we allow many thousand years—at least 30,000—for the deposits to form above the bone. Kent's Hole or Cave is a crevice in the mountain limestone at Torquay, which extends about 150 feet inward, from a narrow opening by the side of the hill. It was probably formed by an earthquake. There is not much land drainage at present into this cave from above, but it has been washed out into fairly large chambers in places. On the interior surface there are many large blocks of stone that have fallen from the roof, and in places stalactite limestone formed from the drippings of a small stream from the roof. There are in places a foot or so of black mold, near the surface, in which have been found Roman coins, sherds of pottery, and other Roman objects. A little deeper there is evidence of the Bronze age, and still deeper of the Stone age (Neolithic). This cave, below the Neolithic stratum, was occupied for a long period by the cave-hyena. The two most remarkable finds in the caves of this district were the palate bones of a hyena that retained the flint weapon, the point of a spear, or a dart, by which it was killed, which happened probably outside the cave, into which the animal retired to die. There was also found a jawbone, of the hyena period, of a man who had probably been its prey. The jaw is of the paleolithic type, with the teeth ground down from eating gritty food. This is universal with the teeth found of this period. Kent's Cave appears to have been alternately inhabited by man and the hyena. Quite at the bottom of the cave, probably before the time of man, it was occupied by the cave-bear and the cave-lion. I have here two teeth which were found in this cave. This cave is probably more ancient than that of Settle.

Peat bogs are formed by vegetable growth in situations where drainage is imperfect, so that the rainfall from higher districts rests as stagnant water, which supports vegetable growth. When such bogs are drained we commonly find the remains of the work of man of all the periods of the formation of the bogs. The Neolithic, Bronze, and Iron ages are all fairly evident at different stages; but the early paleolithic man is seldom represented, except near the bottom, by a few flint flakes, and occasionally by a chipped flint weapon. It is most probable that early man did not pursue his prey into these bogs, from the danger they presented to his life. Of the Neolithic age several boats have been found in the peat, some of which were accompanied by flint flakes, presumed to be used for making them. In the Neolithic period man began to erect lake dwellings. These were wooden constructions built upon piles driven into the bottoms near the shores of the lake. They were most probably built for man's defense against man, when the dangerous savage animals, which were his early enemies, were nearly exterminated. We find in the ruins of these dwellings the evidence that man had begun to cultivate the land (remains of corn), and had domesticated animals for his food, as the ox, goat, and pig. Numerous graves tell the same tale of an advanced civilization, altogether beyond the Paleolithic period. With regard to the chippings of flints to form weapons, this continued right into the historical period. In the earliest implements the chippings appear to be almost accidental. A large number of stones were broken up, one by the other, and the most suitable pieces were selected for the tool or weapon required. This may have been even before the human period. A further advance was made in obtaining fairly uniform shape in ax-like implements. This condition passed through many degrees of refinement until the Neolithic period, when the flint, or hard stone, was quite symmetrically formed, and at a later period was ground to a perfect form. At the same time very great perfection was attained in chipping flints. I have here a flint spearhead of the early historical period that was found at Abydos, in Egypt, in which the quality of the workmanship could not be equaled by modern methods. It must have been a piece of workmanship only possible of accomplishment after great experience. It belongs really to the commencement of the Bronze age.

(To be concluded.)

CHINESE VEGETABLE TALLOW.

THE vegetable tallow tree, known to the local Chinese as the "mu-tze-shu," is found in the mountainous and hilly sections of the province of Hankow. The trees grow in large numbers through the valleys in a semi-rocky soil, and on the mountain sides to an altitude of 2,500 feet. The tree, according to the American consul at Hankow, is of medium size, with heart-shaped leaves which turn a brilliant red in the autumn. The seed pods are seen in abundance on the small branches of the tree, and contain three seeds about the size of a coffee bean, grayish-white in color. As the autumn advances the pods dry up, exposing a cluster of three seeds. These are picked during November, and at once stemmed and made ready for use. They are steamed, and the white exterior of the seed, which is the vegetable tallow, or "pi-yiu," is thus removed. A small brown seed remains, which is ground in the Chinese millstone, boiled, made into cakes, and placed in a press, and a light brown oil extracted from the kernel. This oil is known as "tze-yiu" or vegetable tallow-seed oil, and is used by the natives as a burning oil, and also for adulterating other more valuable oils. The refuse is used as a fertilizer. The tallow is collected, melted, and put into large tubs, which serve as a mold. Blocks of wood are put into each cake, to which ropes are attached and serve as handles. In this form it is brought to the market at Hankow. The seeds, as first picked, yield in weight about twenty-eight per cent of vegetable tallow, and about forty per cent "tze-yiu." The vegetable tallow sells in the market at from twenty-seven and sixpence to thirty shillings per "picul" of 133 pounds, and the vegetable tallow-seed oil at twenty-five shillings per "picul" of 133 pounds, very small quantities, however, of the latter oil being brought to Hankow, as none is exported. The vegetable tallow is used by the Chinese principally in the manufacture of candles, it being of greater consistency than the other oils used for the purpose, and only a small quantity of white wax is needed. It mixes readily, and European firms find use for large quantities in the manufacture of soaps and candles. Great care must be exercised in buying it in Hankow, as much of it is adulterated by the addition of water and other oils, and most of the Hankow shippers have found it necessary to re-melt all the tallow in the presence of the native seller, and so remove any foreign matter. During 1905, according to the customs returns, 20,000,000 pounds were exported from Hankow, while in 1906 the amount increased to 27,000,000 pounds. Up to November 15, 1907, nearly 27,000,000 pounds had been exported.—Journal of the Society of Arts.

THE CONSTRUCTION OF MACADAM ROADS.—II.*

HOW RURAL HIGHWAYS MAY BE IMPROVED.

BY AUSTIN B. FLETCHER.

Concluded from Supplement No. 1700, page 70.

All modern crushing plants are equipped with revolving screens to separate the macadam stones into sizes, and after passing through the holes of the screen the stones fall into their appropriate bins. The "tailings," or stones which are too large to pass through the holes in the screen, run out at the lower end upon a conveyor, which carries them back to the mouth of the crusher to be broken again.

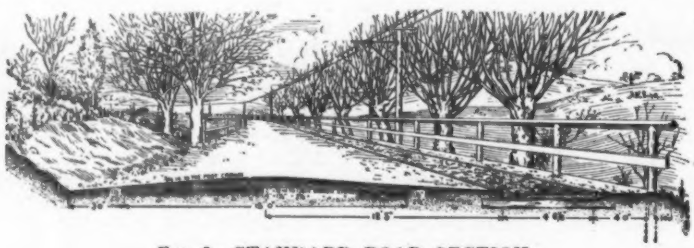


Fig. 6.—STANDARD ROAD SECTION.

Usually there are three sections in the screen; the first, nearest the higher end, has holes sufficiently large to allow fragments not exceeding one-half inch in diameter to pass through. The holes in the second section permit stones 1¼ inches in diameter to pass through, and those in the third section allow stones 2½ inches in diameter to pass through, and all larger stones are forced out at the open end of the screen, where they drop upon the "tailings" conveyor.

The size of the largest holes is determined by the fact that a stone 2½ inches in diameter is as large as should be used in macadam work. These stones are usually used in the lower or first course. The 1¼-inch stones are used in the upper course. If the stones are hard, this size is about as large as can be used to give a smooth surface. Soft stones will often crush under the roller, and sometimes such stones, larger than 1¼ inches, may be used with good results.

The jaws of the crusher should be set so as to make as few "tailings" as possible, and the lengths of the screen sections should also be properly adjusted for the same reason.

Every macadam road should be crowned, in order that the water falling upon it may run quickly to the gutters. It is also necessary that the shoulders should have the same or perhaps a little greater slope than the macadam. (See Fig. 6.)

For a road 15 feet or less in width it will be found satisfactory to have the center 5½ inches higher than the sides, forming a crown of three-quarters of an inch to the foot. On roads of greater width it will be necessary to reduce the crown to one-half inch to the foot, or perhaps even less. The best practice is to make the crown by two slopes or planes, with the apex at their intersection slightly rounded.

Since the wear at the center of the roadway is always greater than at the sides, some saving in stone may be made by reducing the thickness at the outer edges. A layer of loose stones more than 6 inches deep cannot be compacted with a roller easily, if at all, and modern roads are all built in two or more layers or courses.

To secure smoothness and even wearing, the smaller stones should be placed in the upper course and the larger stones in the lower. When a road is built with the sizes mixed, unless the stone is unusually soft, a rough surface inevitably results in a comparatively short time after the road is opened to travel.

When broken stone is spread loosely, as on a roadway before it is rolled, the voids between the stones aggregate between 40 and 50 per cent of the volume of the layer or course. The roller passing back and forth over the course consolidates the stones and a large percentage of the voids, often from 30 to 40 per cent, is eliminated. To secure a finished roadway 6 inches thick, about 8½ inches of loose stones, not reckoning the binder, are necessary. This is in part due to the unavoidable forcing of the stones, to a slight extent, into the foundation.

In the State road work in Massachusetts several sections of macadam are used, the highway commission recognizing that a uniform depth of stone throughout the State is undesirable, because of differences in local conditions. The following table shows the sections in most common use in that State:

THICKNESS OF COURSES OF MACADAM.

Lower course.		Upper course.		Total thickness.	
Center.	Sides.	Center.	Sides.	Center.	Sides.
Inches.	Inches.	Inches.	Inches.	Inches.	Inches.
4	2½	2	1½	6	4
2½	2½	1½	1½	4	4
4	(a)	2	1½	b6	2½
2½	(a)	1½	1½	b4	2½

a The stones are spread as thinly as possible.
b This section is rarely used except in resurfacing a worn-out macadam road.

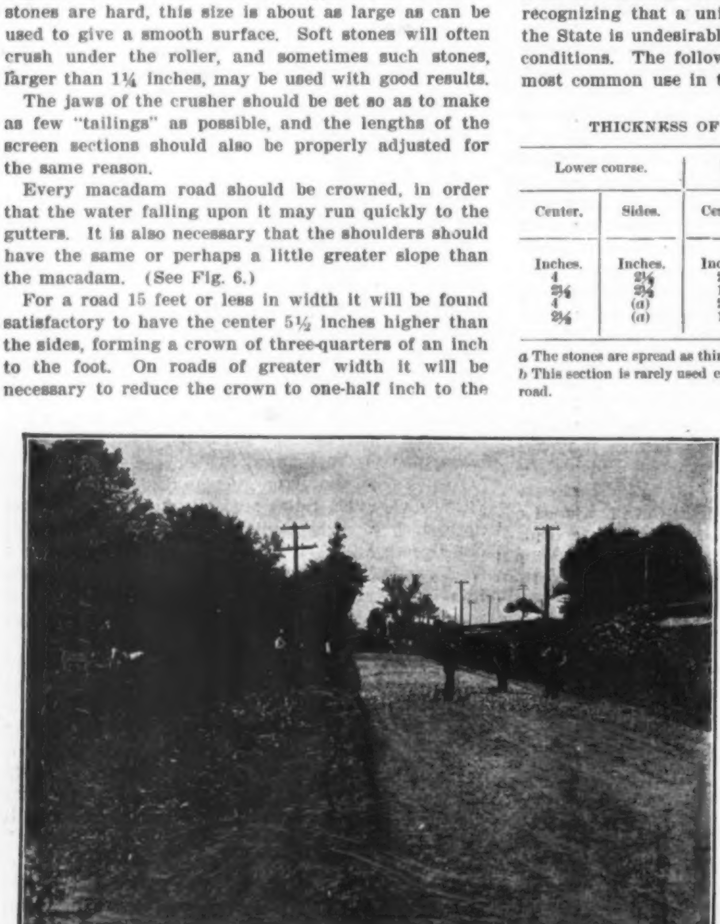


Fig. 7.—SPREADING THE LOWER COURSE.

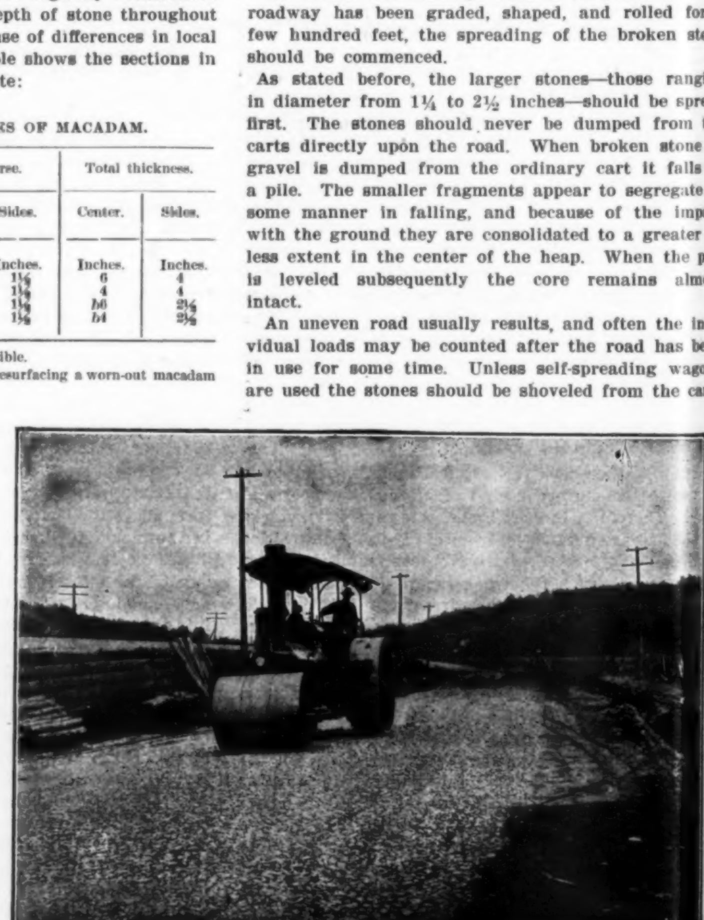


Fig. 8.—ROLLING THE LOWER COURSE.

The binder or "matrix," as it has been called elsewhere in this discussion, consisting of the stone dust and small fragments of stone which pass through the ½-inch holes in the screen, is not counted as a course. No more of the binder should be used than is necessary to fill the voids and to just cover the upper course of stone.

In Massachusetts no stone dust is applied until after the two courses of stone are rolled thoroughly. Then a thin layer of the screenings is spread, the watering cart is brought on, and the "fines" are flushed down into the interstices between the stones. It is rarely necessary to use, altogether, more than 1 inch in depth of the screenings. This method has been followed for a dozen years with complete success.

Under ordinary conditions, no clay, loam, or other like material is needed, either in the interstices between the stones or on the surface, to keep the road from "raveling." In very dry and hot climates, and where the roads are subjected to the ravages of motor vehicles operated at excessive speeds, it may be necessary to apply some artificial binder, such as tar or asphalt oil, and for such places these materials are recommended in place of the clay and loam sometimes used and called "packing."

Sometimes binder, consisting of stone dust, sand, and even clay or loam, is, in certain parts of the country, worked into the first course during the rolling of that course. It is difficult to see how this practice adds in any way to the integrity of the road. On the contrary, it would appear that instead of reducing the voids and so making the road as solid as possible, a considerable portion of the voids are in this way filled with packing, which adds but little to the solidity of the road. The materials used for this purpose are usually cheaper than broken stone and the cost of the work may be thereby lessened a little.

It is true that considerable rolling is saved by this method, and, also, that once in a while, when it is not possible to secure a firm foundation or when extremely hard stone is used, some binder may be needed to keep the lower course in place so that it may be rolled. It may be added that the use of clay should always be avoided.

As soon as the drainage work is completed and the roadway has been graded, shaped, and rolled for a few hundred feet, the spreading of the broken stone should be commenced.

As stated before, the larger stones—those ranging in diameter from 1¼ to 2½ inches—should be spread first. The stones should never be dumped from the carts directly upon the road. When broken stone or gravel is dumped from the ordinary cart it falls in a pile. The smaller fragments appear to segregate in some manner in falling, and because of the impact with the ground they are consolidated to a greater or less extent in the center of the heap. When the pile is leveled subsequently the core remains almost intact.

An uneven road usually results, and often the individual loads may be counted after the road has been in use for some time. Unless self-spreading wagons are used the stones should be shoveled from the carts or dumped on a movable platform of planks, sometimes called a "dumping board."

The spreaders should then shovel the stones from this platform upon the prepared subgrade to the required depth for the lower course, remembering, as before stated, that the course will shrink in depth approximately 35 per cent under the roller. The depth of the course should be tested frequently by strings stretched across between the stakes. Some-

* Abstracted from a Bulletin published by the United States Department of Agriculture.

times blocks of wood of the required height are set on the subgrade and the stones are spread until the top of the course is flush with the tops of the blocks. The stones are frequently leveled with stone rakes. (See Fig. 7.)

When a hundred feet or so of the first-course stone has been spread, the rolling should begin. It will be found best to begin the rolling at the outer edge of the macadam, running upon the shoulder a few inches.

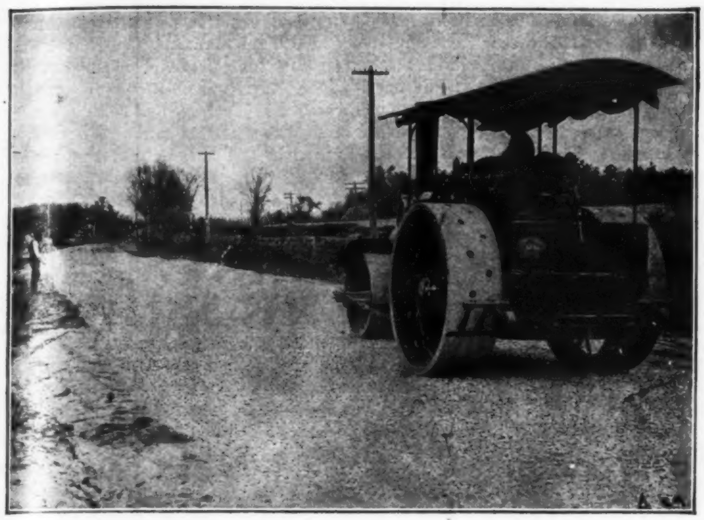


FIG. 9.—ROLLING THE UPPER COURSE; BINDER SPREAD IN BACKGROUND.

FIG. 10.—ROLLING THE BINDER.

When this portion of the stone ceases to wave and seems firm under the foot, the roller should be moved to the other side of the roadway and the operation repeated there. After both sides of the roadway are tolerably consolidated, the roller should be moved gradually toward the center until the entire lower course is thoroughly compacted. (See Fig. 8.)

Sometimes it is found that the wavy motion continues and that the stones will not compact. This may be due to a wet subgrade, which, if allowed a day or two to dry out, will give no further trouble, or it may be due to the use of an excessively hard stone, in which case the application of a little sand or fine gravel may remedy the difficulty. With some soft, coarse, gravel stones, a "crawling" motion may be noticed. In this event, instead of compacting, the sharp corners of the stones become rounded. If the rolling is continued the stones become like marbles. A slight sprinkling of coarse sand, stone screenings, or, in some instances, the application of water, may prevent this action. It must not be expected that the lower course will be absolutely rigid. If it is rolled enough to prevent the stones from shaking when one walks over them it is sufficient.

If depression develops as a result of the rolling, additional stones of the same size as used in the course should be added and rolled, and before the second course is put on the lower course should be smooth and true to the cross section.

FIG. 11.—COMPLETED SURFACE.

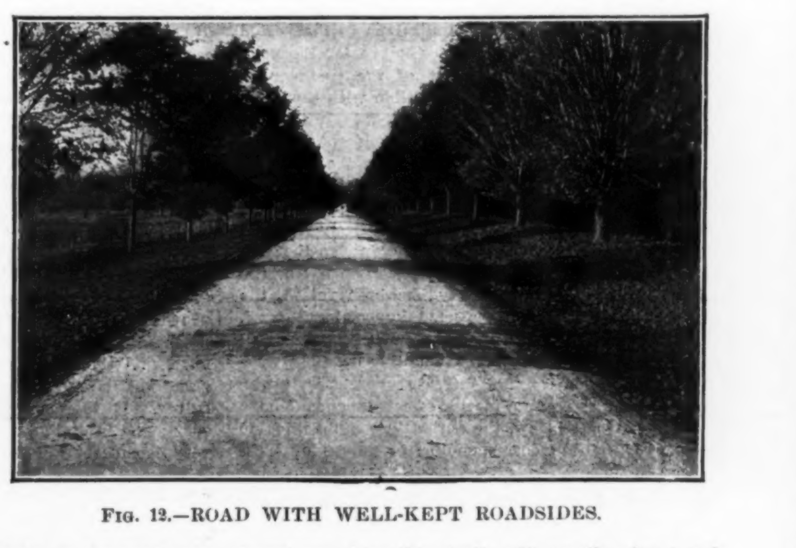


FIG. 12.—ROAD WITH WELL-KEPT ROADSIDES.

After about 100 feet of the first course of stone is rolled, the second course, consisting of the stones varying in diameter between one-half inch and 1¼ inches, should be spread from the dumping board and rolled in the same manner as was the lower course. After the stones are thoroughly compacted the binder should be spread. Usually but little more than 1 inch in depth of the "fines" is required in 6-inch work. The watering cart should then be put on in advance of the roller and as much as possible of the dust flushed into the interstices between the stones. The roadway should be wet and rolled until it "puddles" on the surface, showing that the voids are substantially filled. (See Fig. 9.)

No more of the screenings should be used than is necessary to fill the voids and to leave a very thin covering over the larger stones. Depressions in the upper course should not be filled with screenings, but rather with the stones of the size used in that course.

The ability of the roller operator is a very important factor in macadam work. The appearance of the road surface depends to a large extent on his skill.

No matter how much the macadam may be rolled, it will not acquire the metallic ring usually noticeable in roads of this kind, and showing their hardness, for some days. The calks of the horses' shoes will roughen the surface for a short time, and it is a good plan to keep the roller on the completed road moving back and forth during the progress of the work whenever it is possible.

It is well not to allow the lower course to be spread too far in advance of the upper, and to put on the screenings and water and roll them as soon as possible after the upper course is rolled. There is of necessity more or less teaming over the road during its construction, and while the courses are in an uncompacted condition the horses' hoofs and the wheels of vehicles are detrimental to the work; but when the macadam is completed the sooner it is used the better. (See Fig. 11.)

Someone has said that the maintenance of a macadam road should begin on the day the road is completed. In a sense this statement is not far from the truth. It is usually not necessary to do much to the macadam surface for a year or two, but the gutters, catch basins, and culverts must be kept clean, the weeds along the roadsides cut or, preferably, pulled out by the roots, and the small gullies in the shoulders and on the slopes filled before they become too large.

It is quite possible, particularly if the road was built in the fall of the year and trap rock was used, that loose stones will appear on the surface the first spring after the road is opened to travel. These need not alarm the road official. They should be picked up and stacked for future use. It is astonishing how a few loose stones on the surface of a macadam road will have the appearance of a great number, so that the uninformed always think, and frequently state, that the road is going to pieces. It is a fact that often such stones will disappear into the macadam after the first rain.

Of course the macadam will become worn in time and need repair. No one can state accurately how much of the macadam surface will wear off in a given time. The dictum, heard so often, that the macadam will wear down one-half inch in a year's use is a fallacy. The length of life of a properly built macadam road depends especially upon the volume and kind of traffic over it, the quality of the stone of which it is composed, and its peculiar fitness to resist the wear to which it is subjected, and also upon the climatic conditions of the locality.

It was formerly held that the macadam surface should be restored annually to its original thickness. Doubtless this practice was excellent, so far as the condition of the roads was concerned, but such annual restoration is costly. The present practice is to keep the surface always smooth, to fill any small holes or incipient ruts which may appear, but to do no resurfacing until the stones have worn down at least to the lower stratum of the macadam. Too often the resurfacing is delayed longer than economical considerations will justify.

By the time the upper course has been worn through the road is usually more or less out of shape. As before stated, most of the wear is near the middle of the road. The sides tend to build up as the center wears down. When the road is in this condition it should be resurfaced with the best stone which is available. It should not be necessary to put on more than 3 inches in the center, and the stone at the sides may be spread as thinly as is possible. Usually the road surface is "spiked up" with the picks in the wheels of the steam roller. There are several so-called "scarifiers" on the market, which are sometimes used, but they are seldom needed on country roads. Sometimes no "spiking" is needed if 3 inches or more of stone is put on, since this depth will usually give a sufficient body to hold together.

Such resurfacings are usually relatively inexpensive. There is no trouble with the foundation and the stones settle quickly into place and stay there. When the resurfacing is completed the road is as good as new. Someone has stated that such work should be done in Massachusetts at not exceeding 10 cents per square yard for each inch in depth of new

surfacing material rolled in place. This rough estimate is usually liberal.

In Massachusetts, the State roads, at least 95 per cent of which are of the macadam type, have averaged, for ordinary maintenance, approximately $100 per mile per year. These roads, almost all of which are 15 feet wide in the macadamized portion, have been in service for from one to thirteen years. A few sections now require resurfacing and each year some of this work is done. Only a relatively small part of the resurfacing cost is included in the annual cost per mile above stated, but it is believed that an expenditure of not exceeding $200 per mile per year should be the maximum amount necessary to provide for both ordinary and extraordinary repairs.

At the present time the worst foe of the macadam road is, perhaps, its most ardent advocate—the motor vehicle. The steel wheels of the ordinary vehicle grind off sufficient powder from the stones to serve as a binder, replacing the binding material blown away by winds or washed off by rains. It is usually possible when the binder becomes deficient and the stones in the upper course begin to appear and the surface grows rough, to spread a little coarse sand in the center of the macadam road. The sand is soon spread by traffic over the greater portion of the width of the macadam. It relieves the roughness and keeps the stones from raveling. This practice has been followed in many sections for years. But the swiftly moving motor car of the present day has introduced a new problem into road maintenance. The large rubber tires on wheels of small diameter appear to exert a suction on the binder of the road. The vacuum caused by the vehicle moving rapidly over the road lifts the dust into the air in clouds, and it is blown away into the fields.

Various substances are being experimented with for application to road surfaces to lessen or obviate this evil. Coal tar and oils with an asphaltic base seem to give the best results. In France tar has been used for several years, it is said, most satisfactorily. It may be that by some such application not only will the roads be saved from denudation by motor vehicles but the ordinary surface repair costs will be lessened.

A properly built macadam road in the country rarely becomes muddy except from mud tracked upon it from side roads built of natural soil. The country road official is spared this annoyance and the expense of removing the mud. That they are often dusty can not be denied. Watering or sprinkling is a luxury that can not often be afforded on country roads. When properly applied, water not only lessens the dust nuisance, but preserves the road as well.

No one having had experience in such matters will contend that a macadam road may generally be maintained at a less cost than a gravel or an earth road. Sometimes under certain conditions the macadam maintenance costs may be less, but this does not occur usually. But it is true that a macadam road, such as is recommended in this article, may at a moderate expense be kept smooth, hard, and serviceable at all times of the year, and that these requirements can not be met by either the earth or the gravel road.

NOTES ON MOTOR-CAR DESIGN.*

A WORD ON SUSPENSIONS.

BY F. W. LANCHESTER.

The function of a suspension is in its essence to permit of the road-wheels following the road surface without the rising and falling and oscillating motions being conveyed to the body. In considering the behavior of a suspension it is sometimes necessary to regard the road-wheels and underframes as fixed, and the body as oscillating; but it is, generally speaking, more correct to look upon the body of the car as stationary and the motion as confined to the underframes, as would be the case were a perfect suspension possible.

In the forms of suspension in common employment the elastic connection between the car body and the underframe consists of a combination of springs of the laminated type, giving a considerable range of freedom in a vertical direction, but a comparatively small range of freedom laterally. The lateral freedom is, in fact, so small that the customary type of spring may be said to provide a more or less definite side location.

In practice, owing in part to the slight degree of lateral flexibility of the springs (which may amount to some ½ inch or so), and in part to the freedom permitted by the "shackling" of the springs in some cases, the side location is not so rigid as to enforce the whole of the lateral motion on the body; but in any case the quantity h—that is to say, the height of the side location above the ground level—should be kept as small as possible, for, other things being equal, the amplitude of the side wobble will be proportional to h.

Suspension Period.—The criterion of the "softness" or "hardness" of a suspension is the suspension period; the quicker the period the harder the suspension, and *vice versa*.

If there were no practical limitations to the period attainable, the slower the period the greater the comfort; it is therefore the object of the designer to obtain as slow a period as is compatible with the other conditions.

It can be shown from theoretical considerations that the period of any given suspension is the same as that of a pendulum whose length is equal to the linear deflection of the springs under load; thus, if we suppose that the weight of a car body be entirely removed from the springs by raising it on a crane, so that the weight is just, and only just, relieved, then if l be the height through which the body has been raised, the time period will be that of a pendulum of length $= l$. The equation from which the period of a single or half oscillation can be calculated is therefore the well-known expression, $t = \pi \sqrt{(l/g)}$, where t is in seconds and l in feet. As a matter of convenience, I have given in Table I., below, the period in complete double swings per minute corresponding to values of l expressed in inches:

Table I.—Number of Oscillations per Minute for Initial Spring Deflection = l.

(Inches.)	Complete Oscillations per minute.
1	188
2	133
3	108
4	94
5	83
6	77

* From a paper read at the Incorporated Institution of Automobile Engineers.

Now it is evident that if an attempt is made to obtain the maximum degree of comfort possible, a limit is very soon reached, for a suspension range exceeding a foot is scarcely permissible, and since the range above and below the normal position should be about equal, this means that the equivalent pendulum length is 6 inches, and the number of complete oscillations per minute = 77. In general this is beyond that which is attainable, though I have sometimes nearly reached this figure; 5 inches is the most it is usually possible to specify, with a corresponding period of 81. I have found in practice that a period slower than 90 per minute gives an ample degree of comfort, whereas a period quicker than 100, although frequently employed, should be avoided when circumstances permit.

The whole question of the rolling oscillation, and of the couple, or torque, by which it is set up, is a subject of greater complication than at first sight appears, and only the most brief outline can be given here.

The moment of inertia about the axis of oscillation may be looked upon as the sum of two parts: the moment of inertia of the chassis and body about its own center of gravity, and the moment of inertia of the body as a whole, supposed concentrated at its center of gravity, about the axis of oscillation. Now the first of these is settled once and for all by the body and chassis design, and cannot be altered; the second, however, depends upon the distance of the point of side location from the center of gravity of the suspended mass; this is a quantity that the designer can vary. Thus by raising or lowering the body and chassis as a whole, the second part of the moment of inertia can be made greater or less, or by altering the height of the point of side location above the ground-level similarly an alteration may be made. If, as is frequently the case in a limousine type, the period tends to be too slow, we thus find the designer in a dilemma: he cannot lower the body and chassis as a whole past a certain limit, owing to the underneath clearance necessary; he cannot raise the point of side location without detriment to the perfection of his suspension, both as touching the comfort of the passengers and the wear on the tires; his only recourse is to either stiffen the springs, which quickens the bouncing period and decreases the comfort, or he must widen the lateral spring base—a procedure that cannot be carried beyond a very moderate degree unless the wheel-gage is to be involved. For the above reasons the design of a large, heavy car with much top hamper is frequently a matter of compromise, and the success or otherwise of any given machine will largely depend upon the intelligence of the driver. If the comfort of the suspension alone is considered in design, a car of this type must be slowed very considerably when rounding corners.

There is one important lesson to be learned, however—that is, the value in any case of a low center of gravity. If the center of gravity is kept as low as possible by legitimate means in the design of the chassis and body work, and in the adaptation of the one to the other, the difficulties mentioned are minimized, and a car may be produced with general all-round virtues not otherwise obtainable. It is worthy of note that it is one of the greatest advantages of the combination of a short-stroke engine and worm drive that it permits of engine, gear-box and body work being placed nearer to the ground than in the long-stroke engine and bevel-drive combination.

Suspension Oscillation; Damping.—When a car passes over a culvert or other obstruction the suspension oscillation sometimes persists for several "periods" afterward; and if a further obstruction, or merely an unevenness of the road surface, occurs during this continued oscillation, fitting in with its phase, the amplitude is liable to cumulative increase. Thus, if there be more or less regular undulation of the road surface that happens, at the particular speed at which a car is traveling, to fit in with the natural period of its suspension, the amplitude may easily become sufficient to injure the springs or bring some ugly shocks on to the "check buffers" (if any). The only means of avoiding this evil, which is due to synchronization, is to provide some powerful means of damping the oscillations as rapidly as they arise.

It is one of the virtues of the ordinary laminated carriage spring that it possesses to a considerable degree the necessary damping qualities in its own internal friction. When a laminated spring is flexed it is part of the action of such a spring that its constituent elements (plates) slide over one another, and considerable friction results. This friction may be actual solid friction if the spring is not lubricated, or it may be viscous friction if the plates are well greased. In practice the friction is usually of a mixed kind, in part due to the viscosity of some kind of lubricant.

Let us examine the "classic" method of design for the laminated spring. Firstly, since the bending moment is proportional to the distance from the point of application of the load, and the strength is proportional to the number of plates (presuming the latter all of one thickness), the number of plates must be proportioned to the distance from the end of the spring, so that the plates form a series of evenly placed steps. Secondly, assuming the maximum load condition to be that when the plates of the spring are straight, the condition that the plates shall be subject to equal stress is fulfilled when the plates are initially all of equal radius.

When a number of plates of identical radius are "nested" to form a spring they do not fit exactly, for the external curve of the one bears on the internal curve of its neighbor. Under these conditions, when the plates are pulled together by the buckle they bear firmly one on the other, and set up considerable friction, having the required damping effect when the spring is at work.

Now, if, still supposing the spring to be designed for zero camber at maximum load, we construct the spring of plates of different thicknesses, then the correct initial form for such plates will be such that the radius of curvature varies as the thickness, so that if we make the shorter plates thinner than the longer ones the shorter plates will also be of less radius of curvature, and the pressure between the plates when pulled together by the buckle will be greater than when plates of equal thickness are employed.

From the above it would appear that by designing a laminar spring with the plates of different thickness, so that the shorter plates are the thinner, the damping factor of the spring can be improved. In the case when a spring is under negative load, so that the plates are on the point of separating, the damping action vanishes. It will be noted that this point is reached sooner when the spring is designed of plates of equal thickness than is the case if they are graded in the manner above specified.

Worm-Driving and Screw-Propulsion.—In the early days of the screw propeller it was customary to compare it in its action on the water to a screw working in a solid. It was, of course, recognized that the comparison was not one that could be altogether justified, owing to the fact that the fluid in which the screw propeller operates forms a yielding abutment, instead of an unyielding one. At a time when screws were commonly made of true helical form the yielding of the fluid was represented by the factor termed "slip," and this term is used at the present day in a similar sense, although it is now more difficult to define, owing to the pitch angle of a modern propeller varying from point to point over the surface of the blade. Of more recent years the analogy between the screw working in a fluid and one working in a solid has not been regarded as possessing any serious utility, and it has consequently been neglected; it is only quite recently that my own researches, published in my work on "Aerodynamics," have brought this old analogy up afresh in a new light. In the work in question I have proved that for a blade moving through a fluid, and supporting a pressure reaction, there is a particular relation between the pressure sustained and the square of the velocity of motion at which the total resistance is of least value, and that under these conditions there is a certain gliding angle which is constant in respect of velocity, and whose value is minimum if the correct P/V^2 factor is employed.

The efficiency is given by the expression

$$\frac{\tan \theta}{\tan (\theta + \gamma)}$$

where γ is the angle of friction and θ is the angle of the effective pitch.

The value of θ for greatest efficiency is given by the expression

$$\theta = (90 \text{ deg.} - \gamma)/2$$

or, in other words, it is equal to 45 deg. minus half the angle of friction in the solid screw.

In Table II. this is shown for different values of γ, together with the corresponding efficiencies, which thus represents the outside limit of the efficiency for a worm-drive.

Table II.—Efficiencies of Worm-Drives.

γ deg.	θ deg.	Efficiency.
2	44	0.932
4	43	0.870
6	42	0.811
8	41	0.756
10	40	0.704
12	39	0.655

Gyroscopic Effect of the Flywheel.—The gyroscopic effect of the flywheel of a motor vehicle gives rise, under certain circumstances, to couples of very considerable magnitude.

Employing absolute units, the gyroscopic torque, which we will denote by the symbol τ, is equal to the angular momentum communicated per second—that is,

$$\tau = I\,\omega\,\Omega,$$

where Ω is the rate of change of the precessional angle, I the moment of inertia of the flywheel and ω the angular velocity of flywheel.

Let us suppose that a car of 10 feet wheel-base be traveling at 50 feet per second along a curve of 250 feet radius; let the flywheel have a mean rim diameter 1.5 feet, that radius of gyration = 0.75 feet, and let the motor speed be 20 revolutions per second; then

$$I = 100 \times 0.75^2 = 56$$
$$\omega = 20 \times 2\pi = 126$$
$$\Omega = 250/250 = 0.2$$
$$\therefore \tau = 56 \times 126 \times 0.2 = 1{,}410 \text{ foot poundals,}$$

$$\text{or torque in pound feet} = \frac{1{,}410}{32} = 47, \text{ or at 10 feet}$$

(wheel base) the force representing the gyroscopic torque is 47 pounds. This, compared to the load carried on the front and rear axles, is almost negligible, amounting to less than half of 1 per cent, taking the total weight of the car as 1 ton.

The speed of the precessional motion is limited in practice, so long as a car is being properly driven, by the fact that the speed at which a given corner can be taken cannot exceed a certain maximum. In the example just given the radius of path is such as can be reasonably negotiated at 50 feet per second. When, however, a car is driven round a corner above the limiting speed (which happens most frequently when the road is greasy, since then the limiting speed is lower), it is liable to side-slip, and to acquire a rotational speed about a vertical axis, the limiting value of which we have no means of assessing, and the gyroscopic torque may be increased enormously. Thus, supposing in a case of side-slip, a car turn through 180 deg. in one second—a not impossible proposition—we have $\Omega = \pi$

$$\tau = 56 \times 126 \times 3.14 = 221{,}000,$$
$$\text{or in pound-feet torque} = 22{,}100/32 = 690;$$

an amount that may put the crank-neck in jeopardy. I believe that several of the mysterious cases of bent cranks have been due to this cause; in some cases it has been definitely observed that a crank has been found bent immediately after a serious side-slip. I have only met with one such case personally, but I make provision for this possibility by strengthening the crank-web next the flywheel, and the neck itself, if there should be any doubt as to its sufficiency. I believe the assumption that a car may, when side-slipping, rotate at a maximum rate of three or four radians (= 170 deg. to 230 deg.) per second, gives a sufficient allowance when calculating for gyroscopic torque.

THE AMIDOL DEVELOPER.

SOME GOOD FORMULÆ.

BY C. H. HEWITT, F.R.P.S.

Workers who commenced photography in the eighties developed their bromide prints and enlargements with the ferrous oxalate developer, which gave an image of great richness and fine color if suitable negatives were employed. The utmost cleanliness was necessary, and a microscopic trace of hyposulphite of soda produced pronounced stains. Further, all traces of the bath of dilute acetic acid which followed development and prevented precipitation of iron in the fiber of the paper needed to be carefully washed out, or the hypo was decomposed and yellow stains occurred.

It is not to be wondered at, therefore, that the various modern developers, easier to compound and easier to use, have become so popular that ferrous oxalate is to-day practically unknown to the great army of photographic workers. Of these developers amidol is the chief favorite. The formula is:

Sodium sulphite	1	ounce
Water, up to	15	ounces
Potassium bromide	7½	grains
Amidol	60	grains

To prepare this, the sodium sulphite should be dissolved first, and if the salt is powdered in a mortar and then placed in a large measure, and this is filled up to the 15-ounce mark, the result will be accurate enough, for the quantity of potassium bromide and amidol is so small that it makes no appreciable difference to the total bulk. The potassium bromide may, if desired, be placed with the sulphite before adding the water, and so both dissolved simultaneously; or as there is in all probability a 10 per cent solution of bromide already on the shelf, 75 minims of this may be taken, and so the trouble of weighing out a small quantity will be avoided.

It is sometimes recommended to keep a stock solution of sodium sulphite of the strength of 1 ounce to 4 ounces water, but we have always found the results unsatisfactory. Sulphite of soda in solution rapidly goes off, absorbing oxygen from the air in the bottle (and also from the dissolved air in the water, unless this has been thoroughly boiled and allowed to cool before making up the sulphite solution), and so becoming sodium sulphate. In hot weather this change will take place in a day or two to a sufficient extent to prevent the amidol developer from working properly. The developer, when made according to this formula given, should be used up within the day.

In weighing out the dry amidol the greatest care should be taken to prevent particles being carried about the room by any current of air. Indeed, it is well to weigh it over the sink or a large bench or table which is cleared of everything else, and which can be wiped down with a wet sponge. Particles of amidol settling on a print, for example, will produce small reddish-brown specks, which cannot be removed. After the solution is compounded it should be filtered through a Swedish filter paper to remove the small black specks, which are often very noticeable. The formula given is, of course, in apothecaries' weight. As it must be made freshly, there is little advantage in preparing a stock solution, and the strength as given is right for use for average work. If, however, very large quantities are likely to be required in one day's work, the water may be reduced to 5 ounces, and of such a concentrated solution 1 ounce would be taken with 2 ounces of water added. In mixing developer in this way, or in taking the required quantity of a working solution from the bottle, use an ample quantity for the print about to be developed. A well-soaked piece of bromide paper, lying, as it does, against the bottom of the dish does not require as much developer as would a plate of the same size, but 4 ounces of developer is none too much for comfortably working 10 by 8, and 6 and 8 ounces for 12 by 10 and 15 by 12 respectively. The same lot of developer may be used for several prints in succession, say half a dozen.

While the making up of an amidol developer according to the formula given above is quite a simple matter, and quickly done, there are circumstances under which it is an advantage to have developer always ready. Many workers have odd moments only, and want to run off two or three prints or make an enlargement in those moments rather than to prepare developer. In The Photographic News for April 6, 1906, page 266, the advantages of a neutral solution of sodium sulphite were pointed out, such a solution keeping better than either an acid or the plain and slightly alkaline solution. This neutral sulphite solution is made up as follows:

Sodium sulphite	4	ounces
Potassium metabisulphite	1	ounce
Water, up to	20	ounces

This is a fairly strong solution, and to prevent any of the sulphite from crystallizing out if the weather is cold, the solution should be made up with boiling water, the metabisulphite being added as soon as the sulphite is dissolved. Although this keeps very much better than the plain solution of sulphite, we should not recommend the making up of a large quantity, the temptation often being to mix enough to last for a long while.

From such a neutral solution the amidol developer is prepared as follows, and it is better to mix it of the strength necessary, as a strong solution does not keep any better than if plain sulphite is used, while a dilute solution has fairly good keeping qualities:

Neutral sulphite solution	4	ounces
Amidol	60	grains
Potassium bromide	7½	grains
Add water to make up to	15	ounces

This developer may be used several times. During the recent hot weather 6 ounces of it were used for developing in succession eleven 15 x 12 bromide enlargements, the last of which, however, showed a very slight tendency to greenish-blacks. About 40 ounces kept in a stoppered Winchester were used from as occasion demanded, the developer being poured back into the bottle after use. This kept in perfect working order for several days, which is probably long enough for all ordinary requirements. The longer the solution is used the slower is the development, and developer which has been kept some little time works more slowly, but not sufficiently so to be tedious.—The Amateur Photographer and Photographic News.

In the course of an article on the system of the United Railways Company of St. Louis, in the Electric Railway Review, a description is given of a portable sub-station used by this company for additional feeding of sections of the line where there is temporary heavy traffic. This sub-station contains one 600-kilowatt, 600-volt, three-phase rotary, and three single-phase transformers, together with the necessary auxiliary apparatus. The voltmeters and ammeters are so mounted that they can be easily disconnected and packed in a box of waste, which is kept in the car for this purpose. This was done because it was found that in jolting the car over rough road the instruments were very liable to get out of order. This station consists of two cars, the car containing the rotary being equipped with four 50-horse-power motors, and the transformer car being hauled by this motor car as a trailer. This portable sub-station has been extensively used for special traffic, and was also found of great use on one occasion when a portion of the continuous-current plant in the generating station broke down.

ENGINEERING NOTES.

An electric railway from Martigny to Chatelard was opened recently. The Paris, Lyons, and Mediterranean Railway Company has also completed a short line connecting its own system with the above Swiss line. The new line enables tourists to proceed from Fayet, St. Gervais, and Chamonix to Martigny and St. Maurice, in Switzerland, returning by Evian, Thonon, and Geneva.

One of the most prominent lessons of the Quebec Bridge failure is the necessity for practical tests of full-size steel columns and struts. The subject has naturally attracted considerable attention in the United States, and as a result of the paper read by Mr. J. R. Worcester on "Safe Stresses in Steel Columns" a resolution has been passed by the American Society of Civil Engineers recommending the appointment of a special committee to investigate the design and resistance of such members. A systematic inquiry of the kind would place at the disposal of engineers and architects valuable data, and it is to be hoped that the proposal may be adopted.

Centrifugal pumps driven by steam turbines of the Curtis type are used on two new fireboats of New York city. The pumps are of the Worthington 12-inch two-stage type, each designed to furnish 4,500 gallons per minute against a pressure of 150 pounds. The turbines are rated at 650 horse-power each, with a boiler pressure of 200 pounds, a vacuum of 26 inches and at a speed of 1,800 revolutions per minute. The rotating parts of the turbine are direct-connected by means of a flexible coupling to the rotating part of the pump, and such a unit was found to deliver 1 horse-power at the shaft for every 15 pounds of steam, during a test made at the works.

In the Railway Gazette particulars are given of the longest non-stop run ever made. This run is not exactly unknown, though it is seldom referred to, and the republication of the particulars is, therefore, of interest, especially as the distance covered far exceeds any achievement of British railways in modern days, and so far as we are aware no foreign railway has attempted to surpass our London-Carlisle and London-Plymouth performances. Rather curiously the distance between Jersey City and Pittsburg is not given in the article referred to, but we believe it is 477 miles, covered in 9 hours 57 minutes. This occurred in 1876. It was first attempted in 1875, but the journey was interrupted by one of the main staff being killed by coming in contact with a shed while leaning out to watch a journal. On the second attempt the performance was successfully carried out. The engine and cars (four bogie cars) were specially equipped for lubrication, and the baggage car next the engine carried a supply of coal and a water tank, the coal being passed on to the engine tender and the water being supplied when required. Water was taken several times from track tanks, but the supply in the baggage car was necessary because of the long distance between two of the track tanks. The engine was of the 4-4-0 type, with 17-inch by 24-inch cylinders and 5-foot 2-inch coupled wheels.

In 1899 some fast passenger locomotives having cylinders of 19-inch diameter with a piston stroke of 26 inches were built for the Lancashire & Yorkshire Railway. These cylinders were steam jacketed and the steam was controlled from the cab. The construction was an experimental one and a recent inquiry about the results obtained shows that these results tally with those so frequently encountered in stationary practice. There is a certain theoretical advantage in the use of the steam jacket that does not appear in practical operation, and for that reason it has never been extensively used. In the case of the Lancashire & Yorkshire locomotives, it was not found, after continuous experiments, that it was worth while to steam jacket any more cylinders. The steam jackets apparently had the effect of preventing the accumulation of water in the cylinders, and it was thought that a certain amount of economy was secured by their use, so long as they were carefully watched. That is to say, a good man got good results out of them, while an inferior man got no better results than with the ordinary engines. But they gave trouble from a mechanical point of view, and it was decided that it was not worth while to continue them. Experiments were also undertaken on the same road with a small superheater by which very dry steam was delivered to the cylinders, but owing to the small size that was used a sufficient degree of superheat was not obtained. The experiments were valuable, however, in pointing the advantages to be obtained from a system of this kind, and when the Schmidt superheater was developed in Germany and the results that were being obtained with it became known, a number of engines were equipped with it, and have shown a saving in many instances of 20 per cent. Besides this direct saving, it has been possible to use a lower steam pressure and thus increase the life of the boilers while at the same time there is a better steam pressure and a higher temperature in the cylinders.—Railroad Gazette.

ELECTRICAL NOTES.

Power generated at Niagara Falls is to be distributed all over Canada. Bids have been asked on ten thousand tons of structural steel for the Canadian government. The steel is to be used for towers which will support the cables used in transporting the current. Already power generated at Niagara is being sent a distance of more than one hundred and twenty-five miles, and it is the intention of the Canadian government to increase this distance. Towns in every direction about Niagara will be supplied.

Recently the electric-pneumatic system of railway signaling was brought into operation at the Central Station of the Caledonian Railway in Glasgow. Though the system is in use in England, it has not hitherto been tried in Scotland, so that locally it is causing a good deal of interest in railway circles. The interlocking frame has 300 levers, and the one cabin in which they are situated takes the place of three cabins used with the old system. The long levers of the hand method are replaced by little levers, 5 inches long, the moving of which actuates by suitable electric connections the valves of compressed air motors which work the points and the signals. Points and signals are interlocked electrically as well as mechanically. The air pressure used is from 60 pounds to 80 pounds per square inch, and it is led in iron pipes to each of the motors. The inspection of the installation by Col. Yorke, of the Board of Trade, occupied two days, and after his exhaustive examination he expressed himself satisfied.

An interesting scheme for handling the mail matter of the German capital is at present under discussion, and has been carried out in the shape of a short experimental track. The system is intended to facilitate the conveying of letters from the central post office to the principal stations, the means adopted being a high-speed electric tunnel railway. Each mail train is made up of four trucks, hauled by an electric locomotive. Each truck carries a mail bag. These small trains are unmanned, the current being switched into circuit from the stations. As the train approaches a station the current is cut out automatically. An electric brake is applied and the train enters the post office at reduced speed. The locomotive is stopped by spring-operated brakes, which are released by compressed air. The railways are designed as double-track tunnel lines, passing below rivers and canals. Each truck runs on two wheels. The cost of constructing the first line, which is to connect Potsdamer Platz Station with the letter-mail office in Heiligegeiststrasse, will be $437,000, and on its success will depend eventually the construction of further lines.

For the last twenty years the men in control of the electric railway industry have devoted a great deal of effort to attempting to demonstrate the truth of two propositions: (1) Electric railways render their service for so small a return that they cannot afford to meet demands for lower fares, increased compensation for franchises, and the like; (2) electric railway securities are highly desirable and good-paying investments. Of course, arguments on the first of these were directed to the public in general, while those on the second were intended for the more limited class of investors. Evidently both of these propositions cannot be true, and the attempt to prove too much has been an important factor in the growth of the present anti-corporation sentiment. Whether a railway is really making money after all the proper charges to operating expenses or income have been provided for is a question of fact that should be easy to decide from the company's books, but there are few managements which have the courage to make the true showing when operation is carried on at a loss, until reorganization is inevitable. The general attitudes of the public and of railway officials are well indicated in the Annals of the American Academy of Political and Social Science for May, which is devoted to the regulation of public service corporations. In this number there are eleven papers or communications dealing largely with electric railways. Of these eight are by men who have been or are identified with public commissions or civic reform movements, and all these express the same idea, viz.: There must be drastic regulation—and regulation is tacitly assumed to involve always compulsory reduction in rates of fare or increased service or both. Here proposition 2 is accepted and its logical consequences pressed. On the other hand, the three railway officials who contributed to the Annals, while urging proposition 1, deal for the most part in generalities, and do not give those concrete facts absolutely necessary to determine which claim is correct. The time has come when electric railways should seek rather than avoid close regulation by public authorities; if fares can be reduced and the undertaking still prosper, the reductions should be made; but if the enterprise is losing money under present conditions, that fact should be proved, regardless of the effect on the security market, in order that relations with the public may be established on a sound basis.—Railroad Age Gazette.

TRADE NOTES AND FORMULÆ.

Artificial Wood Substance for Plastic Ornamentation (Bois durci, of Latri, Paris).—This consists principally of freshly beaten animal blood and the saw-dust of hard, resinous woods, pressed into the gas-heated iron or cast steel molds. The forms must be first oiled and the mass steadily forced into them. The mass can be worked, not only in a moist, but also in perfectly dry condition, by spreading it on heated iron plates to dry, pulverizing it and forcing the powder into the heated molds.

To Color Imitation Coral, Made from Alabaster.—Bath: Cream of tartar, 1 part; tin composition, 0.[illegible] part; water, 1,000 parts. Tin Composition: 8 parts nitric acid, 1 part sal ammoniac, 1 part tin, 25 parts water. Add powdered cochineal to saturation and boil; allow to cool, and decant. Place the alabaster in the clear fluid, keep it boiling there for 1 hour, dry it in the air, and finally place it for three hours in a bath of equal parts of stearic acid and wax. Take it out, wipe and polish it.

To Cleanse Corks.—Used corks are placed in a tub with a perforated head. It must be capable of descending into the tub, so as to rest directly on the corks. Pour on boiling water in which to each [illegible] parts there has been added 0.5 part of sulphuric acid. Allow it to stand 15 to 20 minutes, run the water off and rinse out the tub. Treat the whole in the same manner with clear water. Then the same treatment with a solution of 0.13 alum in 8,500 parts of water. After half an hour run the water off. Lay the corks in the sun; in two days they are ready. Do not expose them to the night air.

Graining Powder for Gold Articles (Mathey).—Dissolve 50 parts of molten nitrate of silver in 3,000 parts of water, add a filtered solution of 50 parts of common salt, allow the resultant chloride of silver to settle, decant the supernatant solution of nitrate of soda, wash it by decanting again, add some sulphuric acid and effect the reduction of the chloride of silver by means of pieces of zinc brought in contact with it. Remove the latter, wash off and dry the silver-powder. Mix 1 part of this powder with 6 parts of common salt and 3 parts of cream of tartar, finely rubbed down.

Wood mosaics may be made as follows: Small rods with very small quadrilateral cross sections are made from soft, white wood, colored variously throughout their entire substance and dried. By gluing together rods of appropriate colors a colored picture may be produced and from the block thus formed in the vertical direction of the rods, very thin slices may be cut, which can be glued first on paper and then as veneers on boards. The top surface of the mosaic picture should be rubbed smooth and coated with a lustrous varnish.

Cobalt Paints for Pictures, which change their color according to the amount of moisture in the air.—a. *Purple Red:* 1 part oxide of cobalt dissolved in 3 parts of nitric acid and slowly heated in a glass flask. After solution add basic carbonate of potash until the precipitate is purple red. Dilute with 6 parts of water, then filter and add some gum. *b. Rose Red:* 1 part of oxide of cobalt dissolved in 3 parts of nitric acid, evaporate, after solution, to dryness. Add 1 part nitrate of potash, dilute with 8 parts of water, filter and add a little gum. *c. Yellow:* Brown oxide of copper dissolved in hydrochloric acid under application of heat. The crystals obtained after evaporation (grass green) dissolved in water 1 to 8 and a little gum added. *d. Green:* 1 part of oxide of cobalt dissolved in a flask in 4 parts of aqua regia (1 part nitric acid to 3 parts hydrochloric acid) at moderate heat, take from fire, add 1 part common salt, dilute with 1[illegible] parts of water, filter and add solution of gum. *e. Blue:* Oxide of cobalt, 1 part, dissolved in a flask in 2 parts of nitric acid, poured off into a vessel and potash solution added gradually, allow it to rest and pour off the clear fluid and wash the deposit free from all acids. Allow this to drain and under moderate heat dissolve it in acetic acid (the latter added in small quantities) then add weak solution of gum.

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